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THE

ENCYCLOPÆDIA BRITANNICA

OR

DICTIONARY

OF

ARTS, SCIENCES, AND GENERAL LITERATURE.

SEVENTH EDITION,

WITH PRELIMINARY DISSERTATIONS ON THE HISTORY OF THE SCIENCES,

AND

OTHER EXTENSIVE IMPROVEMENTS AND ADDITIONS;

INCLUDING THE LATE SUPPLEMENT,

A GENERAL INDEX,

AND NUMEROUS ENGRAVINGS.

VOLUME IX.

ADAM AND CHARLES BLACK, EDINBURGH;
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ENCYCLOPÆDIA BRITANNICA.

ENGLAND.

PART III.[1]

GOVERNMENT AND LAWS.

I.—GOVERNMENT.

Formal constitution.

"BY the constitution of a country, is meant so much of its law as relates to the designation and form of the legislature; the rights and functions of the several parts of the legislative body; the construction, office, and jurisdiction of courts of justice." This is the definition given by Paley. It seems necessary to add also, "whatever prerogatives are vested in the executive;" at least, in case any powers and privileges are conferred on it beyond what, from being indispensable to the administration of the public affairs of a community, must be common alike to all executives. Even with this addition, the mere mechanism of a government, in the three principal relations which it bears to its subjects, is all that is here described. Yet something more is generally understood by a constitution, and would seem to be properly comprehended under that name. A government, it is true, may and must be influenced in a hundred ways by independent circumstances, and by manifold considerations, which are no part of it. But when certain specific tendencies and principles are directly and designedly moulded into its original conformation as so many distinct ends and maxims, or when they are subsequently developed by it or incorporated with it, so as to guide and qualify its spirit, they become entitled to the character of constitutional as much as the organization itself. There is no doubt that the mechanism of a government, if left to itself, will mainly determine the nature and direction of its movements; yet this mechanism consists of a moral and intellectual agency. It is accordingly capable of accommodating itself, and of working in subjection to whatever rules and impulses may be impressed upon it by the society whose instrument it is.

No society can be so stationary but that changes must take place, sooner or later, for the better or for the worse, in some one or other of the conditions, whether of principle or of organization, which make up its constitution. When these happen to take place, hardly any society can have been so judiciously constructed from the first, or be so fortunate in all its future circumstances, that lawyers shall be able at once to call every change which is for the worse, unconstitutional, and which is for the better, constitutional. An approximation to this favourable situation has been one of the great and innumerable advantages of the uniform and gradual progress by which the English constitution has been distinguished. Its history is the history of the internal policy of a people, who at every advance in civilization succeeded in occupying one advanced post after another, fortifying their free position at every remove. The early prospect would have discouraged the most sanguine philosopher. But the evil tendencies were suppressed, and the good ones brought forward, until the process appears to resemble the natural development by which a germ grows up into a plant, with but little occasional help from the pruning hand of man. Precisely the reverse might have happened. It is what takes place during that imperceptible decay, which, by a foolish analogy to vegetable and animal life, it has been supposed that institutions are also destined to undergo. The bulk of mankind more easily perceive that abrupt and extensive changes, the innovations by which new principles, or a new organization, are introduced, amount in fact, as far as they go, to a new constitution. This may be done legally or illegally. If illegally, it is a revolution; a case which by the supposition has nothing to do with law. If legally, the letter of the law and the forms of the

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[1] For this part of the article the Editor is indebted to William Empson, Esq. Professor of the Laws of England at the East India College.

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constitution may be used for the purpose of substituting a worse as well as a better government to the extent that the ancient constitution is displaced. The question, what name will most properly describe any specific measure of this class? must depend upon the nature and degree of the measure. There is on these occasions another question for a people, prior in time, and far more important than discussions about a name. It is their duty to ascertain whether the proposed change is, under all the circumstances, a practicable improvement, and to fix where the authority for deciding this point can, upon the whole, be most safely lodged. A comparison of the different methods by which the latter problem can be solved will show what little cause there is for maintaining, as some modern writers are disposed to do, that the course adopted in England is too loose and arbitrary to be consistent with the positive character implied in a constitution.

Three very different systems may prevail in this respect. The two first are alluded to rather than recognised in English history. Its whole tenor proceeds upon the last.

Every country has at one time or another given more or less countenance, upon some favourite points, to the delusion of fundamental laws and unalienable rights; meaning by these, laws and rights incapable of alteration, except by a violence or decay equivalent to the suspension, if not dissolution, of society. Confounding the principle of moral and of legal obligation, Chief-Justice Hobart, from the bench, and Blackstone, calmly writing in his closet for the instruction of the eighteenth century, concur in stating that the supreme power of every state is necessarily subject to one condition. By this condition, all legislative commands against natural justice must be void in themselves, that is, void in law. With much less latitude than has often been given to the law of nature and to the rights of man, this exception might be made to cover extensive and dangerous ground. Lord Coke, for example, has said, that a statute against Magna Charta, or one to prevent the Irish from coming into England, would be void. In this manner the Stuarts were taught by servile judges to believe that most of the prerogatives anciently affixed to the crown were irrevocable even by act of parliament. A similar opinion, grounded on the doctrine of the three estates of the realm, was formerly propagated concerning the episcopal right of sharing in the legislature. At the Reformation, Bishop Gardiner conceived, that in consequence of the forced absence of himself and his brethren, its proceedings would be of none effect. The example was followed, but equally in vain, when, during the violent re-action provoked by Charles I., who considered himself as so pre-eminently a Church of England king, the bishops protested against all acts passed in their absence by a parliament no longer free. Charles I. held the very act by which the bishops were excluded, although some of them attended and voted against it, to be *ipso facto* null. The more intelligent a nation really becomes, the less likely is it thus to presume in favour of the political optimism of its own or of former times. No fiction can be more gratuitously mischievous than the creed that there can be any thing in the force of invading arms in 1066, or in the authority of national wisdom in 1688, or in any length of prescription whatsoever, to disable successive generations from exercising their own discretion respecting the propriety of their existing institutions.

Another plan is to set apart, in a written charter or declaration, certain excepted cases. The high matters which are the chosen objects of this deliberate sanction, are conceived to acquire thereby the privilege of being placed beyond the control of the ordinary legislature, and of being reserved for the direct volition of the body of the people. Locke, in treating of the right of popular resistance, seems to have stated too broadly, that the power of a community can never be exercised in this manner under any form of government, because such a proceeding, he says, presumes the government to be dissolved. Blackstone (vol. i. p. 161) expresses himself still more strongly to the same effect, adding, that no government will presuppose its own destruction. The contemplated occasions are neither as extreme in theory nor as impracticable in execution as this language would represent. There is really no question in this case about resistance, nor what can reasonably be called dissolution. Whilst, on the one hand, the law has nothing to do with possibilities belonging to the ultimate and latent right of resistance; on the other, the idea of a supreme power which may be lawfully resisted in points where it is called supreme, is of course a contradiction. Thus in an absolute government society must be remitted to its first principles before the right of popular interposition can be recognised by it. An ordinance of Louis XIV. declared that the extinction of the family of Bourbon would raise a case of this kind, and that on the occurrence of such event the right of electing to the crown of France would revert to the French people. But limited governments stand in an entirely different position. Minor contingencies, far short of the transgressions which justify an appeal to arms, or of the accident which summons a nation to the *Champ du Mars* to agree upon a successor to a vacant throne, are part of their necessities. The entire legislature may be only supreme *sub modo*. For under the doctrine both of fundamental laws and constitutional charters, every variety of restriction may be imposed upon the legislature. The prudence of these restrictions is more than problematical. But wherever a government consists of several parts possessing coordinate authority, the demand for some external control necessarily arises; since encroachments of one part on the other must be expected; and means ought to be arranged beforehand for bringing them back peaceably within their proper limits.

In this manner, wherever the doctrine of fundamental laws is admitted, a sufficient authority, as, for instance, a high court of justice, should be created for the purpose of inquiring into and correcting any violation of them with which the ordinary legislature may happen to be charged. It will be necessary, besides, to chalk out, as in primary assemblies or otherwise, the extraordinary course by which the policy of the fundamental laws themselves may be reviewed, as occasion shall require. Both these precautions have been introduced and satisfactorily applied by the founders of the United States. But they are not wanted for this purpose by the English constitution. For, notwithstanding a few fanciful conjectures, as above, at times incautiously or intemperately hazarded, the English constitution is not established on any strictly fundamental laws, and still less are any specific questions reserved by it for the direct intervention of the people. But there are analogous dilemmas which may arise under it as a limited and a mixed monarchy. Many, indeed most, of these dilemmas appear to be left open to the chances of unnecessary aggravation, by the want of some similar arrangement. A government, composed of several members with distinct powers, can only exist as such on the supposition that they each remain content with their own share, or that, in case one should trespass on the other, the irregularity can be set right by recurring to expedients legally providing for the emergency. Every one of the triple divisions of the English legislature has in its turn made experimental encroachments, against which there exist but imperfect and often very circuitous guards in the constitution. By the law of constructive contempts, once so flagrantly abused, either house of parliament is armed

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with a despotic weapon. This weapon is beginning to gather a prudential rust in the sheath at present; but the want or the jealousy of a superior court is a poor excuse for allowing it to continue there at all. The mysticism belonging to the maxim that the king can do no wrong, coupled with the recognised absence of any remedy against the crown for any possible amount of misgovernment, proved the ruin of the Stuarts. It encouraged them in the opinion that the supreme power was lodged, not merely in part, but wholly, in the sovereign, and that it might be abused with legal impunity. The 16th Charles II., as renewed by 6 William and Mary, declares that a new parliament shall be called within three years of the determination of the former; but no measures are taken by either statute for the assembling of a parliament in case the king should not choose to call one. The security is left to the old indirect check, the stoppage of the supplies, and to the new one, which, by means of the annual mutiny act, has been derived from a source where an aid to freedom could hardly have been expected, namely, the innovation of a standing army. There is at present abundance of rectifying principle and of auxiliary appliances in the sounder portions of the English constitution, which will prop up the rest, and hold the feebler part to its work. Otherwise the history of the Habeas Corpus act is a striking proof of the inadequacy of all general declarations. In doubtful times these are merely waste paper, unless accompanied by positive arrangements for carrying them into execution, and subjected to proportionate penalties on their infringement and neglect. The act of 16 Charles I. had provided, that if the king neglected to call a parliament for three years, the peers might assemble and issue writs for choosing one; and, in case of neglect by the peers, the constituents might meet and elect one themselves. This act was repealed with great ignominy at the Restoration. But it seems to have left the crown its due precedence, and to have provided, with as little impatience as possible, for the securing an object which all parties are agreed it is absolutely necessary some way or other to secure. The debates upon the command of the militia previously to the breaking out of the civil war, are a memorable instance of the folly of leaving great constitutional rights in obscurity up to the fatal hour when they can no longer be settled calmly and on reasonable terms. If it be important to define rights in times of tranquillity, it is no less so to provide the particular forms by which, in case of violation, the remedy may be applied. It is true that these collisions approach to the character of revolutions. When a king has so far separated himself from his parliament, there is little chance of their returning to that harmony by which alone a constitutional monarchy subsists. No previous arrangements can completely meet the crisis after it has occurred; but they may mitigate its severity, and, by the mere fact of their known existence, may do the still more acceptable service of preventing its occurrence.

According to the third and remaining plan, the constitution recognises the existing legislature as supreme for all purposes whatsoever. To this plan the English nation has always stedfastly adhered. From the time when the commons of England were adopted into the legislature (49 Hen. III.), or shortly afterwards, the legislature has, without any deviation worth mentioning, been the parliament; that is, the king, lords, and commons, in parliament assembled. The popularity of parliaments has been so paramount throughout, that the public have never until recent times been tempted to look elsewhere for rules, inclinations, or opinions. The supremacy of parliament kept its hold, like an anchor which nothing could shake, in the most stormy seasons, and under every variety of circumstance. The impossibility of complying with the customary forms was satisfied as often as it occurred, by the nearest approximation which could be obtained. This was no less remarkable in the course taken as far back as the supposed resignations of Edward II. and Richard II., than on the later occasions of the imperfect convention parliaments. Nobody suggested the propriety of calling together the people to restore Charles II., or to instal William III. into the vacant throne. Mr Hallam observes, that in the combination of gift, descent, and popular election, which took place on the accession of Henry IV. in the year 1399, there was as great formality as in 1688, making due allowance for times and men. The semblance of election remained with the members of the *quasi*-parliament. They had been summoned by the king's writ, but, from not having his commission, they did not take that solemn name, and only called themselves the estates of the realm. Wherever it was possible to preserve by fictions the appearance of a regular parliament, fictions were called in. Thus, during the infancy of Henry VI. the shadow of the royal infant, then only nine months old, opened his first parliament, and made appointments during pleasure. On the derangement of George III. the regency was appointed under the great seal. To keep up the entireness of the body politic of the state, the cooperation and personal will of the king were necessarily assumed in the very act which was to supply his personal incapacity. It was from the court of parliament that Richard III. obtained a confirmation of his alleged title. He rested upon it as "the known quieter of men's minds;" and the Earl of Surrey appealed to it as the one conclusive authority, when taunted afterwards by the successful competitor for the crown upon Bosworth Field. Though Wolsey, "hating parliaments," which therefore hated him, "had been the means that none was holden in the realm but one for the space of fourteen years;" yet Henry VIII. told them that he was informed by his judges that he was never so great as when sitting there in his estate royal. The great test of the omnipotence of parliament was its power of altering the succession. This, which was the established doctrine of the prior period, it was by a statute of Elizabeth made treason to deny. At the beginning of the civil wars, Charles I. called the peers together at York; and the cavalier members seceded from the House of Commons. Under these circumstances a metaphysical question might easily have been raised, as to which was the real parliament. But the locality of Westminster was like keeping the field of battle. It decided the direction of that wonderful and superstitious homage, which made Clarendon complain that "an implicit reverence for the name of parliament was the fatal disease of the whole kingdom." The substance and vitality, however, of the institutions to which the entire authority of national legislation is transferred, are still more important than the name. For this purpose their independence as intelligent deliberative assemblies must be secured. No question can be made concerning open violence. Any attempt by intimidation to force the repeal of a law or a change of measures, or to overawe either house, is treason. But, further than this, no minority or fraction of the people must be allowed to exercise over the legislature an influence of opinion, which the constitution does not attribute to the people at large, or at least does not provide them with the means of exercising. This is a subject of great delicacy; but still there must be some limits. Accordingly, both in law and practice, limits more or less elastic have been put on the nature and degree even of the moral pressure which may be urged on parliament from without.

Tumultuous petitions having been carried to a great excess during the long parliament, the statute 13 Charles II. in consequence, imposed several restrictions upon petitions for any alteration in church or state. But notwithstanding the opinion of Mr Dunning, and the present practice, these restraints have been judicially determined not to be affected by the bill of rights. Mr Hallam says that he has traced public meetings for the debate of political questions no higher than the year 1769, and, subject to very few exceptions, petitions simply political not quite so high. Rights of this kind, guaranteed to the body of the people, and liberally construed, appear to be supplemental to a representation which stops short of annual parliaments and universal suffrage. They are the democratical counterpart to addresses of loyalty to the throne, and of confidence in the government, which are said by Evelyn to have come in even in the time of Cromwell. The right will probably not be used, certainly not used frequently, till a want of sympathy between the representative body and the people, or particular classes, begins to be suspected. The sense of the public, so taken, may often be found to clash with the sense of particular constituencies. In this case, two questions necessarily arise for a member's consideration: first, what weight either one or the other ought to have as mere authority in overruling his own opinion; and, next, which of them, in the event of competition, is entitled to a preference. The same constitutional answer will apply to both difficulties. The inclination on the part of the English constitution appears to have settled down, after some previous oscillation, to one consistent course, as soon as the commons began to feel and act up to their real dignity and strength. A member must necessarily be returned for a particular place. The question is, Are his duties therefore local? The terms of the writ of summons had all along plainly signified that, although chosen by a single district, he was chosen for the wants and service of the realm. Nevertheless many instances formerly occurred of the commons begging for time to consult with their constituents. It may naturally be presumed that this was nothing more than a timid way of evading unreasonable requests. Because their ancestors, afraid of Edward III.'s designs upon their subsidies and fifteenths, had declined to be made consulting parties to his wars, it was absurd in James I. to imagine that he could altogether call away from politics the English gentry of his day. Yet at so late a period no less a person than Burghley condescended to argue against the propriety of the interference of the House of Commons in matters of war and peace; and to take the distinct ground that its members by its institution had minds only of a compass each for the place which he served. But parliament had already heard the contrary within its walls. The movement of society which had made it impossible to execute the statute requiring the member of a district to be an inhabitant, had brought out, in the reign of Elizabeth, the first parliamentary declaration in behalf of the complete legislative authority of members of the House of Commons, in full accordance with the letter and conditions of the ancient writ. In the declaration that members were to act not only for their constituents, but for the whole kingdom, it was evident that a great principle was proclaimed. If sycophants then contested it, Mr Hallam, speaking of modern days, says very truly, that it is one which at present "none but the servile worshippers of the populace are ever found to gainsay." The weightiest arguments in Burke's letter to the sheriff of Bristol, against particular instructions, are little more than the application and extension of this principle. The necessity of going back to their constituents for a specific assent, was one of the main grounds of that incompetency to the duties of a representative assembly which facilitated the ruin of the states-general of France. A few votes beyond what a question would have obtained upon its general merits may thus be stolen, and a few individuals may thus push themselves forward into temporary notice. But public opinion can never be truly ascertained, any more than the public interest comprehensively promoted, by desultory and individual pledges. For this purpose the public must act in concert. With this view, kings of England have sought to satisfy themselves and the House of Lords with regard to the reality of the public sentiments, by a dissolution addressed to specific points. On the occasion of Mr Fox's India bill, the new members were expected to bring to the House of Commons an answer concerning the royal choice of particular men as ministers; and on the occasion of the Reform Bill, concerning the policy of a particular measure. This is the utmost advance which the English constitution has made towards admitting the doctrine of the will of the people or the instructions of constituents. So narrowed, it is a proper, and at times an indispensable part of every rational system of representation. It is practically quite consistent with the general rule that the select body of electors are trustees for the entire community; and that their representatives are the only organ by which the public will is on all subjects ultimately and conclusively expressed.

This then is the English system. It seems to be an extreme and fanciful subtilty to doubt whether the title and character of a constitution can properly belong to it. It is something in its favour that it can appeal to experience as practically embodied in a government, now of ancient standing, at once the most progressive and the most permanent which the world has ever yet seen. Why is it less a constitution because it gives to its ordinary contemporary legislature the most plenary attributes of supreme political power, and because it disclaims the supposition that its early constitutional legislation had or could have the sanction of any higher authority? The assent of any one generation can be of neither greater nor less value than that of another. It is not wonderful that a society, setting up for itself for the first time, or obliged by circumstances to begin anew in an enlightened age, should try to build upon the basis of fundamental laws. But it is fortunate for a constitution, of which the first stone was laid in haste and ignorance, and in the dark, and which nevertheless always kept so far in advance of its contemporaries, as to serve other nations for the model whence the criticisms have been derived by which its irregularities were afterwards to be condemned, that it started with no similar pretensions. If it were to suit the ages through which it was to endure, it could only do so by a plastic mode of conformation. In this manner its people were educated along with it and up to it, the two acting and re-acting upon each other. Hence an instinctive intelligence and conformity, otherwise almost unattainable, appear to have been secured, which political changes have hitherto slightly disturbed. Some bad logic, and a few incidental anomalies, are a small price to pay for conciliating opinions and smoothing over the transitions through which, in the course of centuries, an improving nation has to pass. But the mode in which these alterations have been made is objected to. The body of the people, it is said, ought to have legislated upon them in their own persons. It is surely a sufficient answer that it would be difficult to name a year, when in point of fact more would not have been lost than gained by tying up the hands of parliament, and putting its legislature to the circuity of an appeal to the freeholders of the county courts. The nature of things does not admit of there being any greater security for good government than can be given by a legislature of which a popular representative assembly, properly chosen and seasonably renewed, is a member. To call in the people to council, is to abandon to that extent, under circumstances too of great probable excitement, the advantages of representation; and for no countervailing benefit, unless on the singular supposition that a people incapable of choosing able and honest representatives, will be found capable of being able and honest legislators themselves. The device is much more likely practically to delay improvement than to check encroachments; since, for the latter purpose, the restraints it imposes are either unnecessary or insufficient. There can be no substitute for the spirit of a people. With that spirit, these precautions are not wanted; without it they are vain. The two cases which look most suspicious in English history (one in substance, the other in form) are the proclamation-statute of Henry VIII. and the septennial bill. The parliament of Henry VIII. gave royal proclamations in certain cases the force of law. The extent of the innovation has often been exaggerated. But, with regard to the present question, there can be no doubt, that a generation which by royal order changed its religion four times in twelve years, would, on the subject of royal proclamations, have as readily acceded to his majesty's desires. A few corporations petitioned against the septennial bill. But an observer of the prior, contemporary, and subsequent conduct of the body of the people on this point, and a reader of Burke's speech against triennial parliaments, will perhaps see little reason to believe or to wish that the people, if calmly consulted, would have come to a different conclusion. It should be recollected, that the question is one of pure argument only, and not of history. By the common law a parliament, unless dissolved, lasted for the king's life. In 1694 this duration was first shortened to three years; but in 1717 these three years were lengthened to seven. Thus, the law of triennial parliaments, spoken of by some as an almost vital part of the English constitution, was never known in England but for neither more nor less than the space of twenty and three years.

Every government is characterized by the ends which it proposes as its primary objects, and by the means which it applies for the attainment of its ends. These objects represent what is vaguely called its spirit. The only means properly at its command refer to the making, interpreting, and executing laws. It follows that the most important distinctions in this respect between one government and another, must be found in the specific provisions which determine the formation and distribution of the legislative, judicial, and administrative power. The English constitution is a limited or mixed monarchy; limited, by the maxim that the king has no rights but those which are prescribed and ascertained by law; mixed, by the fact that the parliament, in which the sole legislative authority resides, consists of the king and the three estates, the nobility, clergy, and commonalty of the realm, as comprised in the two houses of Lords and Commons. The suppression of partial interests is sought to be attained, and the practical recognition of the great end of government, namely, the happiness of the whole body of the people, has been principally developed and enforced by the share which the people exercise more or less in the government. This takes place in the legislative department, by means of their representatives; in the judicial, by the agency of the jury; in the administrative, by the doctrine of official responsibility, and from the example and control of a great diversity of popular local municipal institutions.

A more considerate legislation is promoted by a second legislative assembly. A great addition is also made to the political stability of a limited monarchy, by forming the members of this second assembly into an hereditary nobility. A mixed government has, however, a still greater advantage. It naturally leads to and facilitates a division of powers, which is the most important of all the checks that mere arrangement can produce. According to this division, the authority of parliament is strictly confined to the original enactment of the laws. The duty of the judges is as strictly judicial. They have no more to do with the politic administering of the law than with the making of it. The law being thus made, and thus interpreted, the entire charge of carrying it into effect is vested immediately or mediately in the crown. Whilst the several parties who make, interpret, and execute the laws, are kept, in this manner, perfectly distinct, it becomes exceedingly improbable that any confusion, either unintentional or wilful, should arise between the principles properly belonging to their several operations. This is a caution which the cause of public liberty, as well as that of civil justice, alike imperatively require. Blackstone[1] has expressed a strong opinion as to the propriety of the executive being only a branch, and not the whole, of the legislative; also[2] that the judicial authority should in some degree be separated from both. This was one of the points on the paramount importance of which Jefferson and Adams were agreed when they came to apply the experience of the English constitution to the construction of their own.

Eastern nations, notwithstanding their supposed immemorial civilization, appear never to have got much nearer than the inhabitants of the South Sea Islands to a conception of the just foundation on which alone the rights and duties of sovereignty rest. On the other hand, the citizens of Greece and Rome were fully aware that political society was grounded on the advantage of its members. Their patriotism was not more exalted by the pride of national independence than by the consciousness of being responsible only to the law. Nevertheless, the real condition of these great commonwealths was for the most part in lamentable contradiction to the individual ability and virtue by which their history has been made famous throughout all ages. The glory of free and classical antiquity was frequently clouded, and was brought at last to an abrupt and final termination. This is apparently to be attributed to the defective mechanism of their institutions, more than to any other cause. Their construction and division of the legislative, judicial, and executive authority were all along so imperfect, that their negligence of the means of a better political arrangement can only be accounted for by their ignorance of its necessity. There is nothing to this effect, even in their theoretical works upon government, when carefully examined. Polybius, it is true, gives the preference to a combination of monarchy, aristocracy, and democracy, as being in a degree more stable than the simple forms. Cicero also agrees with him in saying, that this was the true Roman constitution; but he most unwisely adds, in compliance with the Roman jealousy of kings, that wherever the executive is placed in a single hand, the government is mixed only, not tempered, and must be ruined by the vices of the individual. Different writers appear to have meant different things by the same word. Aristides denominated the government a mixed one as late as the time of Marcus Aurelius. Tacitus saw through the fictions, and thought that the word implied more, otherwise he would scarcely have said that such a combination may be more easily praised than effected, and that were it effected it

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[1] *Commentaries*, vol. i. p. 146 and 154.

[2] *Ibid.* p. 269.

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could never be lasting. In case, however, the constitution had done nothing further than realize the above combination in the general sense which alone these philosophical statesmen were contemplating, it would have stopped infinitely short of the principal benefits which it has conferred. The separation of the three great branches of political authority into distinct departments, as it is one of the most probable consequences of a mixed monarchy, so is it beyond all comparison the most valuable. Unfortunately it had not taken place under the imperfect specimens of mixed government with which they were acquainted. It is not surprising, therefore, that in theory the philosophical truth of such a corollary should never have occurred to them. If that consequence had been duly presented to his mind, Tacitus must surely have seen reason to question the cycle of Polybius, and to feel greater confidence in the political contrivance by which the efficiency and the durability of states have both been found in practice to gather equal strength. No political phenomenon can be more interesting than the circumstances and the method by which a government has thus arrived at the high distinction of first uniting improvement and stability, liberty and order, and has been enabled to combine the greatest of all ends with what, from the failure of the most celebrated experiments, it may be well supposed were means very difficult both to discover and to apply. Sanguine spirits often appear to imagine that as good a constitution as can be devised may be struck out and fitted upon at a moment's notice. The history of the English constitution may teach them greater caution. A distinct examination of its respective parts will show, not only how slowly they have been formed, but to what extreme risks at different periods the existence and the principle of each have been, and perhaps must be, severally exposed.

The English constitution is more historical than philosophical. It has been the gradual development of national good sense, shown in a spirited and prudent improvement of tendencies and events, without any of the ambition of a regular, preconcerted system. Its object was never stated in a declaration of the abstract rights of man, nor its organization derived from a metaphysical analysis of the elements of human nature. He must have been indeed a prophet, who, at the time of the Norman conquest, could have foreseen the course by which it would outstrip the feudal monarchies which resembled and surrounded it. The difference lay in this: For successive centuries, circumstances played favourably for a people who had the merit or the good fortune to profit by them as they occurred. M. Rey is so far right. England has experienced the truth of Aristotle's observation with regard to Crete. An insular position has great advantages for political experiments. Assistance has also frequently come in from the most unlikely quarters, and the scale has more than once been turned by causes to which, as far as we can observe, no nobler name than that of accident is to be assigned. At one time the very strength and concentration of the monarchy of England, as compared with the weakness of the monarchy of France, brought the barons, the people, and even the church, into a closer union for their defence. At a later period the impoverishment of the crown by foreign wars, and the alienation of the crown lands, brought it into dependence upon, what was most fortunately, one national parliament instead of several distinct provincial assemblies. The separation of the greater from the lesser barons, the assembling of the commons and the lords in different chambers, the transit through which the exemptions claimed by the clergy became disqualifications, the conversion of the jury from their original character (whatever that may have been) into a popular tribunal, have turned out to be the hinges on which English freedom has ultimately turned. They are instances of incidents, in themselves at first comparatively trifling, diverted by circumstances into a deeper channel, or transmuted by a noble alchemy into a much higher purpose than what was their original purview and intent. Although the English government was from the first a limited monarchy, it was not for nothing that monks and lawyers lent a hand in the pious frauds of forging tales about Alfred, Kentish privileges, and imaginary Saxon laws, or in encouraging the more recent fiction of the notorious anti-tallage statute. The stoutest antiquarian who ever argued that the title of William the Conqueror represented merely the feudal *conquisitio*, and not the conquest of the nation, nevertheless must admit from time to time great historical distinctions. The nature and degree of the limitations practically needed and applied to the powers and mechanism of the several component parts of the government varied exceedingly at different periods. The importance even of the grand division between the legislative, judicial, and executive authorities, was far from being at once recognised and observed.

Changes in society and opinion.

A constitution upon paper and in practice are such very different things, that we must look into the history as well as the laws of a country, in order to know at any given time what was the real contemporary character of its government. English antiquarians have been more or less successful in tracing back the dates of their most popular institutions. But the sense in which the same institutions were in point of fact understood and administered at different periods, and the security which they were capable of affording, are distinct and much more interesting questions. A people and their government, it is true, are always cause and effect to each other; and none more so than those of England. In the present instance, however, there can be no doubt but that the narrative of English parliaments and of English juries establishes their existence, as a matter of pedigree, long before there was spread throughout the community either the spirit, the knowledge, or the means to turn them to their legitimate account. The systematic regularity of modern governments was unknown even to the ancient republics. No wonder, therefore, that it was wholly unthought of either by the feudal chieftains themselves, or by the rude vassals who attended to do suit and service at their courts. Our ancestors were satisfied, we are told, with the rough standard of measurement taken from parts of the human body, though differing in different men, till Henry I. ordered the *ulna* or ell, which answers to our modern yard, to be made the precise length of his own arm. To lay down any thing like a precise standard for civil obedience, was left for later times, and for arms still stronger than those of any king. Even long after the golden rules and metewand of the law were recognised at Westminster, acts of violence were frequent over the kingdom, with more or less remonstrance; so that *judicandum est legibus non exemplis* is a maxim which the constitutional inquirer is obliged to keep constantly before him.

The history of England opens with a society divided into castes. The distinctions taken by the law were onerous and severe. There is a great difference between Glanville and Beaumanoir. Nevertheless, the blot upon Magna Charta itself, in the limitation (*liber homo*) cannot be explained away. The later threat of Richard II. after the unsuccessful insurrection to which the peasantry had been driven by oppression, is equally intelligible. Their condition, he told them, should be made yet more miserable. The statute of labourers, which was passed in the reign of Edward III., was in the same spirit. It continued to be a no less absurd than wicked favourite with after-

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times. It is impossible to look over the whole intermediate legislation concerning the lower orders down to the reign of Elizabeth, without perceiving that most of its provisions are as much statutes of police as of trade. They have the air of being expressly directed to the object of preventing the consolidation of the different degrees of society into one people. When we compare the laws of England in this respect with those of the continent, we cannot estimate too highly the comparative equality of ranks, and the absence of exclusive privileges. Nevertheless the laws were bad, and public opinion worse. The dialogue on the Exchequer, written towards the close of the reign of Henry II., observes, that in all cases of secret slaying, whether of English or Norman, the penalty should be levied on the hundred, "unless there are plain *indicia* of the servile condition of the deceased." The petition of the commons to Richard II. that villeins might not be put to school and so get on in the church, "for the honour of all freemen," was re-echoed two hundred years later, in the cry against the Lord Cromwell, on account of his "villein blood." The class was then about to disappear. It is evident that it was only by its extinction that prejudices incompatible with real equality under a free constitution could be removed. The gradual elevation of the entire population into the condition of freemen, put all ultimately in possession of rights which had been wrested from the crown by feudal leaders and independent yeomen with a much more partial object. It took ages to compass this emancipation, and to reverse the proportional shares of the national wealth, as held by the king, the church, the nobility, and the commons. If all the land of the kingdom had continued to be the portion of the church, the king, and the immediate tenants of the crown, who, according to the list in Domesday-book and Brady, did not exceed seven hundred in number, this consummation would never have been accomplished. Civil wars and commerce, by scattering properties and displacing chivalry, broke up the feudal system much more effectually than any positive enactment. The possession of property gave leisure; leisure, especially when the reformation and the press stirred up the human mind with new and more liberal excitements, gave knowledge. Even without the strength of numbers, the combined influence of property and knowledge must give power. Until the body of a people has obtained the intelligence necessary to understand something of their own interests, and the power of making an attention to their interest and feelings a matter of prudence on the part of the higher classes, it is in vain to expect that just principles of government will be steadily acknowledged, much less that they will be steadily put in practice.

The king appears in the law-books as the source of almost every institution and every right. There is no other independent political existence save his baronial court. Nevertheless, as far at least as concerned the people, the king was originally still more powerful in fact than even in law. There was always a legal control upon him. But it was lodged at the beginning in an assembly where as yet the people bore no part. Bracton, who wrote under Henry III., probably not long before Leicester's writs to knights, citizens, and burgesses, appears to have as little anticipated them as he could have anticipated their effect. In his perversion of the imperial law to the purposes of a limited monarchy, he declares that the will of the prince must be according to his counsellors; that is, of "his court of earls and barons." He terms them his "associates," and makes them his superiors; for he adds, "were the king without a bridle from the law, they ought to put one on him." The court of peers, or royal council of France, by the non-attendance of the tenants in chief, sunk into the great judicial tribunal of the country, and became known by the name of parliament, after the time of St Louis. The peers of England were not so confident of their feudal exemption from supreme legislative control; consequently, when, about the same time, or a little earlier, the *aula regis* or great council of England assumed a new form, it separated into two compartments; one judicial, or the supreme courts of justice; the other legislative. The last consisted originally of the earls and barons only. By the time that the incipient House of Commons became its colleague, the name of parliament was appropriated, and, from its omnipotence over the feelings of the English nation, has become almost consecrated in their behalf. It was long before the parliament felt its strength, or knew how to use it. In the mean while the constitution, directly or indirectly, within doors and without, kept making head. During the struggles which the crown, reign after reign, was maintaining, sometimes with different members of the royal family, at others with the aristocracy, and at others against the church and papal usurpations, the people became important as allies. The people appear on the whole to have judiciously sided, where, according as the temporary pressure was felt to bear, it was for the interest of the public that they should side. It is difficult, owing partly to the uniformity which prevails at present, to comprehend the sudden turns which this instinctive policy might call upon them to make.

A sagacious and honest yeoman may have been with King John to-day, and with his barons to-morrow. To look merely at property: the Conqueror retained in his own hands fourteen hundred manors, the reserved rents on which Burke, in his Abridgment of English History, reduces to L.70,000 of the money of that period. The resumption of the grants of Henry VI. was prefaced by a public declaration that his ordinary income did not amount to more than L.5000. In the next reign we find Edward IV., independently of parliamentary supplies, the owner of above a fifth of the lay property of the kingdom. Within half a century the scale had again changed its balance. Wholesale confiscations, succeeded by the minuter and more politic arts of Henry VII. humbled the pride and broke the combinations of the nobility. Although the nominal rental of the royal demesnes was reduced to L.32,000 at the accession of James I., yet the idea of any danger to the monarchy from aristocratical competition was almost a faint tradition at the time of Lord Russell's trial. He justly exclaimed, in allusion to the apprehension, "We have no great men now." Previously to this revolution in society, it depended for the most part on the personal capacity and character of the sovereign, whether the contingencies to which a wise constitutional jealousy ought to have been most alive, would come from the turbulent intrigues of the aristocracy, or from monarchical ambition. The royal prerogative attracts the first and the liveliest attention, as its power is always present and most promptly felt. Besides, it was absolute in language, prominent in form, and often irritating in the subject and occasion of its exercise. But all the great points whence a cloud might have arisen over the freedom of the nation had been soon foreclosed, and, in spite of occasional, indeed numerous violations, were closely watched. There is no denying that many remaining prerogatives were absurd and even odious. Still the nature and the danger of the grievances to which the people were legally and practically exposed from them are usually overrated. The Stuarts let no prerogative drop willingly; and it is well known that they laboured hard to revive some that were obsolete. Yet Lord Bacon declared, on presenting an address to King James, that there was no grievance in the kingdom "so general, so continual, so sensible, and so bitter, as the prerogative of purveyance." Nevertheless, what did it amount to when represented in money? From one cause or another, the commons receded from their negotiation, rather than buy off this their master grievance, and that of military tenures into the bargain, at the cost of an annuity of L.200,000. In the interval which elapsed between the depression of the nobles and the rise of the commons, the monarch had the stage comparatively to himself. The crown also at that critical moment passed into a line of able and haughty princes. Mr Hallam observes, that constitutional freedom was consequently retrograde from Henry VI. to VIII.; yet it is evident, from what passed during that period, that the hardy plant was not only alive, but safe. Bills in the form of acts, instead of petitions, which by adding to or diminishing from what the commons had petitioned for, had been for ages scandalously abused, begin with the reign of Henry VI. The first writ of habeas corpus, apparently so simple a result of Magna Charta, was obtained against Henry VII., the wiliest of the Tudors. Elizabeth had her father's spirit, and can scarcely be suspected of relaxing a hold which she could have decently retained. Yet in 1586 the House of Commons first succeeded in bringing the inquiry into election returns from out of chancery before themselves. By unfairly selecting the arbitrary passages from the reign of Elizabeth, and misrepresenting them as the ordinary course of her government, Hume gave both colour and currency to sophisms, which betrayed a much greater passion for ingenious paradox than for historical truth. The English people are wrong, it seems, in charging the Stuarts personally with the misgovernment which provoked the great rebellion. That misgovernment is represented to be nothing more than a continuance of the ancient English constitution, such alone as their ancestors had known it. According to this statement, the fault of the Stuarts would have consisted in carrying down the prior constitutional misrule into times which would no longer bear it. If such had been the fact, it is a fact which those times must certainly have known. But the understanding of contemporary parties was plainly all the other way. History has preserved the positive admission of Charles I. to the contrary, in a reference too remarkable not to prove that he was himself conscious of, and was aware also that his subjects knew, the whole extent as well as spirit of his innovations. What a satire on his own and on his father's government, that he should, in 1640,[1] hold it out to his parliament as a boon, that he would return to the precedents of a sovereign whom they had already endeared to the people as "Good Queen Bess;" whose reign, however, we know, notwithstanding, to have abounded with tyrannical executions, gross and frequent enough, it might have been thought, to have satisfied any of her successors. It is not the less true, that the time had come when the authority as well as the ceremonies of the court must undergo mutations, at which minds, with much larger views of government than that of Clarendon, would be startled, and perhaps annoyed. The state of society required popular changes to be admitted, for which no precise precedent could be found. Under these circumstances, men like Selden, for instance, a little too apt not to look for liberty beyond their law-books, must often have felt embarrassed how to act. The Stuarts, however, did as much as could well be done towards relieving their subjects from difficulties of this description.

Unluckily for the Stuarts, none of the innovations which they attempted, nay not even the consistent system to which it had been their object to bring the practice of their government, were so new and so outrageous as the principles on which they professed to reign. No country set a higher value than England, whether it was pleaded on behalf of the prerogative royal, or in the much more reasonable case of civil possessions, on the somewhat too stationary title of prescription. The coronation oath on the one hand, and the oath of allegiance on the other, the theory of the feudal system, and many passages in their annals, had accustomed them to look to a rough notion of contract as the criterion of submission. The divinity studies of the early lawyers, and the usages of the puritans, tended to influence the thought and language of modern times by the course of authorities in the Old Testament. But these views were common property. All went there for what they wanted, and all found it. The partizans of despotism and freedom, Hobbes and Locke, Bossuet and Algernon Sidney, discovered, the two first in Chronicles, the two last in Deuteronomy, arguments for their opposite systems. It was far otherwise with the novelty which the Stuarts took up, and made the creed of their supporters. The new creed was precise and positive, and the whole spirit of English history was in contradiction to it. No later than the 13th Elizabeth, a statute had been passed, declaring it treason to maintain in any wise that the king and parliament had not the power to limit the succession. It was natural to lament that the feeling of feudal attachment was decayed. But the doctrine of a divine hereditary patriarchal right was a strange invention to replace it withal. The cavalier loyalty of Ormond belonged to former days, and had nothing in common with the superstition of Mainwaring and Sancroft. Principles utterly inconsistent with all that had been ever written on the subject, almost with all which had been ever done, became the favourite and insulting theme of speeches, proclamations, sermons. Thence the dread of the convocation sitting after the dissolution of parliament; thence the unanimous resolution that their new canons would not bind even the clergy; thence the protests against the new pulpit law, to make the king more absolute than his predecessors. Roman Catholic ecclesiastics had put their hands to Magna Charta. The Oxford decree was the boast of the Church of England. The latter books of Hooker, on account of their heretical latitude, were to be made out to be fabrications; whilst Jeremy Taylor, the great ornament of his profession, pronounces that there are few cases of conscience in which a man may hope for half as much conviction as on passive obedience and non-resistance. Non-resistance was soon improved into absolute compliance. It became, in other words, the indefeasible legitimacy of modern days. These prodigies of doctrine defeated themselves. They misled the governors and provoked the governed, and, in James the Second's expostulation with the seven bishops, returned them their poisoned chalice to their own lips. A limited monarchy and unconditional allegiance are a contradiction in terms. The only consequence of allowing to a brave and thinking people rights and privileges in the statute-book, and yet closing up every practicable channel through which, if they are violated, a legal remedy can be obtained, is the generating a spirit which sooner or later must force itself a way by some great convulsion. Another revolution, and the example of a new dynasty, were made necessary to establish the truth of the opinion which Gourville expressed in vain to Charles II.: "A king of England who will be the man of his people, is the greatest king in the world; but if he would be any thing more, he is nothing at all." So evident, indeed, has it ever been since the Revolution, that no king can long carry on the government upon any other terms than by becoming the man of his people, as represented in parliament, that the royal legislative negative has fallen into abeyance for a century and a half. Elizabeth, at the close of one session, rejected forty-eight bills which had passed both houses. The last exercise of this prerogative was in 1692, when William III. refused his assent to the bill for triennial parliaments. With the modifications, and under the circumstances in which alone the negative of the president of the United States can be interposed, it is easy to see how the head of that republic may prudently venture on the exercise of a power to which it would be the height of imprudence in a king of England so far to put himself in opposition to both houses as to revert. It cannot be said that the change is in the mode of operation only, and that the king does now by influence what he used to do by prerogative. It is notorious that, on several occasions since 1692, influence has failed in doing that which the acknowledged prerogative would have done by its single word. The result is, that the king, who for many centuries was more powerful in fact than in law, is more powerful in law than in fact at the present time.

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[1] "At the opening of parliament, the king very frankly delivered himself to the lords and commons, and was resolved to follow their advice in repairing the grievances at home, which he confessed the necessities of the times had brought upon his people. All those, whether in church or state, he was willing should be removed, and desired that all things might be reduced to the good order and practice of Queen Elizabeth; which to the people of England were sure looked upon with the greatest reverence." (1. Clarendon, 519.) This important passage is printed for the first time in the last edition. It is one of the worst omissions in the former garbled text. The speech is imperfectly given in the parliamentary history, with a rather later date. It is in itself a complete answer to the comparison laboured by Hume. The truth is, that the Stuarts had a dread of English history, for its testimony against them. Bishop Nicholson observes, in his *Historical Library*, that the publication of the second part of the Glossary of even the orthodox Spelman was supposed to be delayed, because he had called Magna Charta, *Libertatum Anglicarum diploma et sacra anchora*; and that in 1614 the Society of Antiquaries was suppressed on account of the jealousy manifested by James I.

If under the same forms the rise of the commons has changed imperceptibly, but entirely, their relative position with regard to the crown, this has happened to a still greater extent between them and the barons. The power of the nobility consisted in their immense possessions, in the clan-devotion of their dependents, in their territorial jurisdictions, and in the original superintending authority of the supreme feudal court. The blow struck at their properties, both by force and artifice, speedily took effect. The shake once given was so certain of spreading further, that the formation of new aristocratical fortunes out of the monastic confiscations has never been made an imputation on the policy of Henry VIII. It was as the favourite of Elizabeth more than as the lord of Kenilworth, that Leicester succeeded in making the gentry of Warwickshire wear his livery. The original relation between lord and tenant implied protection on the one hand, and obedience on the other. If the tenant could not alien without the lord's license, the lord could not transfer the tenant's seignorial dependence without the consent of the tenant. The social movement, commencing at the top, naturally occasioned a relaxation in these duties and sympathies on the part of the lord in the first instance. This broke the charm. It soon became evident that king-maker could be the title of no future Warwick. There had been a series of concentric circles, through which the feudal feeling rose from the vassal of the mesne lord up even to the throne. But all gave way at once. It was clear that the mischievous distinction between a king *de facto* and a king *de jure* could not be recalled, nor the allegiance of the subject transferred from the regal office of the sovereign to his natural person and blood royal, when once the feudal feeling lower down the ladder had been so completely destroyed, that, in the words of the age of Selden, an English tenant would be the first person to lay his landlord by the heels. The landlords and the sovereign have been both amply indemnified in increased security, for whatever either may have lost. At the same time the constitution and the country have been infinite gainers by the general adoption of a more rational patriotism. The civil exemptions which the peers possessed in their individual character were all along insignificant. The judicial authority vested in their territorial jurisdictions was superseded by circuit judges, and by justices of the peace in every county. That which had been reserved to them collectively was of a kind more honorary than formidable, and one which there was little temptation to abuse. The small value which they attached to their power as a civil tribunal is proved by the intermission which took place of all writs of error to the lords from the time of Henry IV. till the accession of James I. Their criminal jurisdiction, except in the case of impeachment, was confined to the members of their own order. From the time that the commons were united with the lords, and their joint assent became equally indispensable to all legislative measures, the sole undivided glory of Bracton's baronial court was at an end. A statute of Edward II. declares that every legislative measure not sanctioned by the consent of king, lords, and commons, shall be void. It states also that this is according to custom. Nevertheless it was long before the commons had the courage to act upon this supposed equality. Sometimes they stultified themselves by way of policy, to avoid any possible responsibility. On ordinary occasions they felt themselves overshadowed by the neighbouring greatness of the lords. Thus they applied to them on great emergencies, begging that they would send some of their members to instruct them in their duty (as in 1st Richard II.), "on account of the arduousness of their charge, and the feebleness of their own power and understanding." In the same manner, on the insanity of Henry VI. they left the establishment of the regency with the peerage. "You, the peerage, in whom, by occasion of the infirmity, resteth the exercise of his authority." In the reign of Charles I. the commons are seen for the first time taking the lead, and carrying the lords along with them. Several of the lords in that crisis gave in their adhesion, and co-operated with the commons. Before this, the spectacle of their concurrence had always been, the commons walking in the train of the lords. New principles must accompany such a change. The House of Peers could no longer claim the privilege of legislating exclusively for the benefit of their order, nor proceed on the distinction that they sit in their own right, answerable only to themselves; whereas the House of Commons, as a representative body, is answerable to the people. The sophistical distinction can hardly serve at present to prop up the privilege of their proxy; a pretension not less incompatible than popular instructions with the first duty of a deliberative assembly. Fifty years ago, when Paley first published his Moral Philosophy, the peers had so far fallen into the back ground, and political reasoners had so far learned to look to reason only, that Paley defends the institution of a House of Lords as a part of the British constitution, on grounds which would have amazed Simon de Montfort, and perhaps somewhat scandalized John earl of Somers. His main argument is founded on the use of a second and totally distinct legislative assembly, in order to protect the state against popular caprice and fury. Ever since the Revolution, the *momentum* in English legislation has lain necessarily in the commons. The king and the lords have both sought to keep there a hold, by way of influence, so as to fight their

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battle in that field always in the first instance, and thus procure an additional guard against the chances of more direct collision. The reform bill has to a certain degree stopped up the communications by which this arrangement had been in substance effected ever since, and, in fact, long previously to, the Revolution. Mr Hume remarks, on the existence of two legislative assemblies, separate from each other, yet each of them supreme, as one of the great anomalies of the Roman institutions. The characteristic danger of such a state of things exists also wherever the consent of two or more men is required in carrying on public business. The only difference is, that the danger in the latter case is often counterbalanced by greater advantages; and that the mischief will probably be less violent from their opposition in the passive shape of refusing to legislate in the same direction, than in the more active shape which their opposition might have assumed in Rome, that of positively legislating, one against another. It is evident, however, that a society, the elements of which, by the supposition, are not paralysed and torpid, must soon find out the means of evading the evils of a political stale-mate. The necessary unanimity can be only obtained by reciprocal compromises and forbearance. If we will have the benefits peculiar to such institutions, we must be content to pay the price. In the administration of justice, the limits which separate pertinacity and weakness is one of the difficult discretionary questions which judges and jurors have to settle with their respective colleagues. If every member of a jury or a senate were to be as impracticable as Cato is described to have been, institutions of this nature could in no country be allowed to last a week.

Mr Hume and Mr Bentham appear to agree in thinking, that in the case of numerous assemblies called upon to determine the much more extensive and variable questions which arise in the general conduct of political affairs, it would be unwise to rely upon the exercise of a similar discretion, as sufficient security for the analogous compromises which are nevertheless indispensable conditions to an efficient co-operation. For this purpose they both acknowledge the propriety of some species of influence, which shall make the one to a certain degree dependent upon the other. In such a case the only question which remains practically to be argued will be its nature and the mode and degree of its exercise. If Dr Paley gives too much countenance to influences approaching to a sordid bias, Mr Hallam, it may be feared, is somewhat too confident in the assurance that moral influences will of themselves always secure a just, or at least an adequate, concurrence.

Polybius has shown that the simple forms of government, however suited originally to this or that stage of society, necessarily become in time unsuitable. What he describes as the specific germ of decay, "congenite in each form," would be more properly described as an alteration in society itself. This alteration drags the government after it into the requisite modifications of its form. It is one of the great merits of a mixed government, that, without the violence of a revolution, it can accommodate itself to these changes in a community, and pass the initiative with comparative facility from one class to another, just as the leading shoot in society may happen to be making head. Under a nominal invariableness in the balance, some variance in the weights must always be going on. The crown was not easily content to resign the ascendency it once enjoyed. When the higher classes had to outward appearance ceded the political powers they had formerly possessed, they were enabled afterwards by circumstances to continue in the covert enjoyment of it, to a much greater extent and a much longer period than any one could beforehand have presumed. James I. probably was not aware of the tendency of the proclamation by which, on calling his first parliament, he directed the sheriffs to address the writs upon a principle substantially the same as the late reform bill. There can be no greater proof, on one hand, of the respect of the people of England for ancient forms, and, on the other, of the moderation by which the higher conciliated the jealousy of the middle classes, than the fact that the adoption of this principle was postponed during the next two hundred years. In those classes, including the gentry and independent commonalty of the realm, in whom for some time past the heart's blood of the country has mainly been formed, the reform bill has at last placed the command of the House of Commons. The power which this portion of the community before exercised indirectly over the whole parliament, and especially over that house, it now exercises directly. The consequence is, that there is a much greater security than before, that no measure detrimental to their interests, and in opposition to their feelings, will be agreed to by a House of Commons of which they are themselves now made the constituents. There need be no fear for the duration of moral frame-works like that of government, on the ground of their supposed analogy to the growth and decay of material forms. There seems also no better foundation for the inference drawn by Polybius, in his comparison between the governments of Carthage and of Rome as they existed at the time of the campaigns of Hannibal, where he says that a mixed government, in which the preponderance has passed from the monarchical and aristocratical to its popular members, has run its course, and is so much nearer to its termination. Difficulties enough remain inherent in the nature of all government, which no possible adjustment of the machinery can reach. But a mixed, though incomparably safer than a simple, government, has some difficulties peculiarly its own. It depends on a nicer balance of proportions, and it calls for a greater degree of temper, patience, and mutual concession from its members. A rational and public-spirited House of Commons must be in constant danger of offending one or other of the extreme parties in the state. Whilst its honest concurrence with the other branches of parliament must frequently incur the displeasure of the demagogue and his mob, the sovereign or the peerage, one or both, are often not unlikely to regard its general or particular opinions with equal jealousy. A constitution thus settled is only safe as long as the more intelligent part of society can take advantage of its intermediate position, and arbitrate between the extremes. A House of Commons, identified with the great arteries of the nation, contains within itself no inherent security for good government, beyond the power of stopping bad measures, and of sending good ones up for their acceptance to the other partners in the firm. If they accept, well; if they reject, a class of cases arises, on which all the good sense and good humour of a country may be wanted, in order to guide a people to discriminate aright on the course which it becomes them to pursue. Unless a power of rejection, according to a liberal construction of independent judgment, be conceded, the whole benefit of a second assembly will be altogether lost. The power of rejection may, however, be so exercised by a headstrong monarch or by a small hereditary body, especially when, in the case of the latter body, the greater part of the legislature have been recently raised to the peerage from the ranks of one political party only, as to amount to a declaration that they are looking only to themselves, their own interests and passions. A civil disseverance from the sympathies of the nation, like that of the Roman Catholic clergy, justifies the extreme remedy of removing the obstacle by whatever

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means. The occurrence of such fatal obstinacy in the person of the sovereign, would be an exception to every presumption upon which hereditary monarchy is engrafted on a mixed government. The contingency of so remote and so insane a possibility could only be formally counteracted by some such expedient as is adopted with respect to the veto of the president of the United States. In the instance of a refractory House of Peers, the constitution has given the king the means of applying this remedy by a creation of additional peers. This course was taken by Queen Anne on a much more questionable occasion, namely, for the sake of a mere ministerial majority. It is not the less clear that a justifiable occasion might occur. If the king took courage to apply the constitutional remedy, all would proceed as usual. If he shrunk from it, the public would be remitted to those ultimate considerations of civil prudence which are always in reserve. They are the very same considerations which justify the sacrifices of natural liberty which men must make upon entering into a commonwealth. They may equally justify the sacrifice of social order which man is called upon to make whenever a commonwealth is overturned. It is to higher authorities than the precedents which are to be found in Rushworth, that freemen have recourse when they are compelled to seek new modes of legislation by forms which announce that the constitution has been destroyed.

The spirit and effect of institutions and of measures depend, as has been shown, in a great degree upon circumstances beyond themselves. The same institution at different periods produces very different results, whilst the collateral and unforeseen consequences of a measure are frequently much more considerable than the objects which its framers had in view. All that is most important in the present forms of the English constitution, is of a certainty to be traced, however obscurely and imperfectly, from a very early date. At the same time, it has become what it is, only by making the most of a series of fortunate contingencies. The English government may be advantageously compared with the Roman in its best characteristic, the tendency to progressive self-improvement. In the nature of the improvements there can be no comparison.

According to the process pursued, the substance has been in a course of much more extensive alteration than the forms. With regard to the latter, the change has chiefly consisted in removing partial impediments out of the way of certain movements, in strengthening particular springs to meet particular pressures, and in separating the several parts of the mechanism by more positive divisions, lest they should clash one with another. The manner in which the English clergy overreached themselves, by standing on their claim to exemption from temporal jurisdiction, and on their right to be taxed for temporal purposes, if at all, by themselves only, and in an assembly of their own, is very instructive and curious. They chose to remain apart, a separate estate; and resisted the attempt of Edward I. to incorporate the inferior clergy in the House of Commons, when that house as yet existed mainly for taxation. They procured their convocation about the same time instead of it. Afterwards, in its palmy state of general legislation, they discovered, when it was too late, that their exemption was turned into an exclusion. In 1663 the supreme head of the church of England found it no longer necessary to keep up appearances with a body already but a shadow. Without a law, a struggle, or even a word, convocations have died away. The clergy, on submitting to taxation by a temporal assembly, have acquired in return the humble privilege of voting for the members of a house in which they cannot sit. A few bishops in the upper house are all that remains in the English institutions, of that third estate which was so necessary a part of the diets and states-general of the continent, and which made so great a figure in our own original constitution. The suspension of the royal negative, and of ecclesiastical convocations, has, almost unobserved, become part of the modern English system. Yet the change which has been thus operated is far more important, though it is short of what it is sometimes represented, than many which have been the subject of fierce contentions, and introduced by the most deliberate enactments.

Legislature.

The transitions which we have hitherto been considering, are independent of and paramount to legislation. They follow slowly but necessarily the variations in the condition of society and in public opinion, which must decide nine tenths of the materials and spirit of every government. We proceed, therefore, to consider the principal alterations which positive legislation has successively effected in the three great divisions of political power.

The main objects of a government have been mentioned as being the making, interpreting, and executing the law; the first being the office of the legislature, the second that of the courts of justice, the third that of the executive administration. It will be proper to examine each shortly in detail, both as to its duties and its form. The English legislature, acting together as king, lords, and commons, is vastly too cumbersome to take upon itself the detail of the executive. This union, therefore, has never been thought of. Its incompetency either as a whole or in its parts to discharge judicial duties is not so soon perceived; consequently bills of attainder, of pains and penalties, and impeachments, are part of the legal history of the most recent times. In the infancy of courts of justice, and when the traditional supremacy of the *aula regis*, out of which both they and the legislature had emanated, was yet an active historical recollection, parliament in all extraordinary cases continued to claim an original judicial authority. But this pretension gradually dropped, and the appellate jurisdiction is now evidently near its close. Regarding the legislature in its legislative capacity only, it will be seen that its form has remained the same as a whole since the first admission of representatives from the commons. The changes which have taken place have been confined to the construction of its constituent parts, and to the view taken of the characteristic rights peculiar to each.

In considering the several members of the legislature, the king takes constitutionally the precedence. Nothing can be more superficial and incorrect than the view presented by Blackstone of early English history upon this part of the subject. It was not until the accession of Edward I. that the several titles of election, descent, and testament, on which the claims to the crown were before rested, as best served the occasion, became consolidated in that of hereditary descent. This appears to have taken place in analogy to the descent of land. The rival pretensions of the houses of York and Lancaster tended to throw the law once more into confusion. Being principally tried and determined upon the field of battle, the law had too much the appearance of giving way to force, or to its hollow consequence, a mere ostensible election. Yet, even in those times, there was no notion that the crown was left at the personal disposal of the monarch. William the Conqueror, it is true, had set up a donation from Edward the Confessor. But Richard II. on giving his signet to the Duke of Lancaster, as testifying his wish that the latter might succeed him, added, "but that did not depend upon his pleasure." The lords, in a remarkable lecture to the protector, the Duke of Gloucester, whose powers under the will of Henry V. had been limited by the parliament (for lords and commons are mentioned in the act), say his desire was grounded neither in precedent nor law; " the which the king that dead is, in his life, nor might by his last will, nor otherwise, alter without assent of the three estates, nor commit or grant to any person government or rule of this land longer than his life." The extraordinary provision of 28 Henry VIII. c. 7, is the first and only instance of putting the crown into settlement, with a remainder " to such persons as the king by letters patent, or last will and testament, should limit and appoint." It is plain that the testamentary power so granted to her father had puzzled men's minds in the time of Elizabeth: and that temporary authority to bequeath the crown has to answer for the strange and almost oriental scene by which the death-bed of that princess was disturbed. Since the Revolution, however, the parliamentary title is the one established in fact. Since the reign of Elizabeth it had been the only one recognised in law. The king never had a legislative initiative, but only a simple concurrence. The change of the form from petitions to bills, took away no right, but only an abusive advantage. The real legislative authority of the crown still continues in point of law the same that it has ever been. It was at no time more than at present, at no time less. The right to make law by proclamations, and the right to unmake it, whether by the repealing *dissimulavimus* of Edward III., or by a dispensing and suspending power, were always arbitrary usurpations. For these are utterly inconsistent with the principle, and almost with the letter, of the statute of Edward II., which had declared the assent of the lords and commons to be as necessary as that of the king; since the maxim that the same solemnity which bound is required also to unbind, is a rule of English law. The disuse of the royal negative since the reign of William III. is purely matter of discretion; however paramount the political necessity by which that discretion is determined.

The peerage was formed, under the feudal system, upon the principle of tenure, that is, of land held directly of the king; the mitigated sense in which the soil of the western world was understood to belong to the sovereign having been always very different from the absolute ownership of the sovereigns of the East. At the first, all tenants in chief had a right of summons to parliament, not yet known, however, by that name. During the period which elapsed between the demise of John, the last year of whose reign is remarkable for the division of the greater and lesser barons, and the middle of the reign of Richard II., when peers were first created by letters patent, tenure began to be disregarded. The political principle had so far got the better of the feudal, that in the 49th Edward III. the ancient writ of summons was changed from homage to ligeance. The further difference in the form of this appointment, as whether it was to be made by writ or patent, was of little consequence. But the dispensation from the necessity of holding land in chief was an important innovation. On the one hand, mere territorial possessions, distinct from descent, ceased to confer a title to a writ of summons; on the other, the writ in its general form might easily in time, by multiplying cases of dependent poverty, have turned this august assembly into the lacqueys of a court. It was well that a sense of dignity took the other course; though disfranchisements on account of poverty, as the act degrading the Duke of Bedford in the reign of Edward IV., and the resolution against Lord Ogle in the reign of Edward VI., were precedents liable to be abused. The questions, where the power of creating peers should be lodged, and the terms on which it should be exercised, were likely in early times to be determined by other circumstances than reason. The mode finally adopted, by which the power is intrusted to the sole discretion of the crown, appears to be, upon the whole, the most desirable. Yet the prerogative was so unsettled in practice, and probably also in law, that down to the reign of Henry VII. the assent of parliament was generally expressed in patents of personal creation. Upon this usage West founded his theory, in opposition to Prynne, that such assent was a necessary condition. Whatever may have been understood to be the law, the practice was liable to all the objections so triumphantly urged against the bill twice proposed by Lord Sunderland in the beginning of the last century, for limiting the number of the peerage. Whilst a restraint upon the royal prerogative of creating additional peers would occasion more evils than it could cure, no similar risk accompanies the withholding from the crown a power of punishing by exclusions or of privileging by exemptions the actual members of that body. Accordingly, Lord Coke holds that even dispensations, answering to the excuses formerly besought by poor boroughs, granted by the king in relief of lords petitioning to be spared the burdensome service of attendance, were contrary to law. The mode in which the prerogative of creation was exercised varied with the times, but never seems to have been felt to be a grievance. The jealousy of the Stuart creations before the breaking out of the civil wars, and the remonstrance against the Scotch and Irish honours, was only a temporary ebullition. The degradation which the decay of families might have brought upon so much of the peerage as was called by a general writ of summons, came to a certain degree within the control of two principles: the one, that a patent without words of inheritance is simply a dignity for life; and the other, that peers might be summoned only to a single parliament. There are instances of ninety-eight laymen who were summoned only once, of fifty others who were summoned two, three, or four times. The present course, however, of descendible nobility, is as old as the reign of Elizabeth. The uniformity of our modern usage would be corroborated, amongst other causes, by the contemporary extinction of a corresponding variation which had previously subsisted in the summons of the ecclesiastical members of the House of Lords. The bishops are said to sit by a usage compounded of a triple title. They are supposed to be the representatives of the church, to have been more learned counsellors than the lay nobility, and to be the life-proprietors of the baronies attached to their sees. The last condition, however, is wanting in the sees erected by Henry VIII. But parliamentary bishops formed a small portion of the spirituality in the upper house. Out of one hundred and twenty-two abbots and forty-one priors, who occasionally sat previously to the dissolution of the monasteries, it appears that only twenty-five abbots and two priors were constantly summoned. There are numerous instances of the allowance of exemptions to abbots and priors after summons, by reason of their holding nothing of the king. This ground of exemption, as insisted on and admitted, shows *whence* the duty was derived. It does not follow but that the grounds of *right* on their part might be more extensive. It is according to this distinction that the writ requiring the attendance of the temporal nobility by summons, belongs to a period and style when its duties were an *obligation*, and were recognised as such; the patent to a period when they had become an *honour*. The most important parliamentary change, however, which collaterally resulted from the dissolution of the monasteries, was the subordinate condition to which it reduced the church numerically in the House of Lords. This alteration was likely to diminish the general political influence of the church much more than the subsequent cesser of the convocation in 1663.

The authority of the convocation being confined to the clergy, the public at large had little immediate interest in its operations beyond the share which they might therein please to assess themselves by way of ecclesiastical contribution towards the public burdens. In point of fact, the temporalities even of the church seem to have lost nothing from either cause; much less its substantial influence. Few will think, whilst the clergy have been shut out from the commons, and lowered down to the compliment of a single bench amongst the lords, that their friends have not done for them behind their backs quite as much as they could have done for themselves if present. The influence of the church of England in its apparently almost unrepresented and unprotected state, is a great proof how little comparatively depends on the means by which an end is to be produced, when a power, composed of a wealth, an intelligence, and an opinion competent to produce the end, is really in existence out of doors. Although the dignitaries of the Roman Catholic church varied in numbers from time to time, yet they always formed the actual majority of the House of Lords up to the Reformation, which, nevertheless, they could not stop. Here, again, with what prudent reserve did the Roman Catholic clergy husband for ages the political power which mere numbers vested in their hands; and how evident is it that, whatever form, even of superstitious incarnation, the dominant spirit of a government may assume, it is only by compromises that it can subsist. The Stuarts, the great examples of every species of political misrule, would have been ruined by this alone; they were bent on acting up to the very extent and margin of their powers. Nobody reading English history previously to the Reformation would have an idea that during all that time the temporal nobility were in a minority; that therefore their legislative importance existed only by permission; and that every act of the House of Lords might be said to be in strictness the will and pleasure of the church.

The number of the lay nobility has fluctuated considerably. It had advanced from fifty-five in the reign of Henry VIII. to one hundred and six in that of James I. It is at present three hundred and ninety-one. The aristocratical complaint made by Lord Delamere under James II. that, ever since the time of Henry VII., a systematic project had been pursued to humble the peerage, by means of multiplying its numbers, and by introducing into it persons of mean extraction, was particularly injudicious. Unless something of this kind had taken place, the extreme disproportion between the two houses, in their external as well as in their personal titles to consideration, would have deprived the peerage of a great part of its present strength. If the order was to be more than a pageant, it became most desirable to increase its numbers to the extent of giving them a better chance of bearing some comparison in ability and character with the select representatives of the rest of the nation. It was scarcely less so to recruit into their ranks those members of the commonalty who, whatever might be the obscurity of their pedigree, were most distinguished for their wealth or services. Thus alone could the body have been protected against the narrow sense of corporate pretension which must otherwise have infected it. The long recollections which feudalism has left, and the recent jealousy which has collected around corporations, notwithstanding their former usefulness, demonstrate the depth of the national re-action, which all invidious exclusiveness unavoidably provokes. In fact, no amount of popular opinions has been sufficient to save the combination of the great Whig families from a suspicion of aristocratical tendencies of this description. The popular criticisms on the corn-law legislation of landed proprietors are a proof of the keenness which watches every supposed connection between public policy and partial interests. An evil not quite similar, but equally, indeed in all probability more, destructive in its consequences to the object and safety of the peerage as a branch of the legislature, must follow, whenever its vacancies are too long filled up from a particular party in the state. It is self-evident that the chances of a difference of opinion between a House of Lords partially constructed, and a popular House of Commons, cannot be raised with impunity beyond a certain point. Under the most accurately-balanced government, the question, whether the Lords shall at any time interpose their legislative negative, must of course, as in the case of the king, depend at last on their own discretion. The difference in practice is found in their respective positions. There can scarcely remain a possible presumption in favour of the single opinion of a chief hereditary magistrate, when a majority of the nation, aware of that opinion, is found constitutionally ranged against him. On the other hand, abuse in their original appointments, and ignorance of the duties and necessities of their station, must have gone to an extravagant length indeed before a body of the nature of the House of Lords is put in equal peril by the rejection of whatever measures may be sent up to it by a majority of the House of Commons. Take either extreme; a House of Lords in constant collision with the Commons, or a House of Lords only occupied in registering its edicts. In the former case, it cannot exist long; in the latter, it is already existing only in name.

The popular part of the English constitution is lodged in the House of Commons, which originated in the year 1295; and, in its present extension, consists of the representatives of different interests or sections of the community, by individuals of their choice. It is very singular that the simple expedient of popular representation, an indispensable condition to every form of a free government in a great kingdom, never occurred to the legislators of antiquity. By this device, the experiment of a free government is entirely changed, and becomes, under all circumstances, infinitely more practicable, safe, and beneficial. According to the ordinary theory of the English constitution, the House of Commons is said to represent the whole population, as far as it is supposed to be by its circumstances independent. Of these, the knights, or the members returned by the freeholders of the county, are alleged to represent the interest concerned in agriculture; whilst the citizens and burgesses, or the members returned by certain towns, have been described as representing the interest concerned in trade. The basis of English representation, at first very limited, and long extremely fluctuating, was never so extensive as to answer to the first part of this theory; and time rendered it, by the rise of some places and the fall of others, still less so. The reform bill has probably more nearly approximated towards realizing the theory of a representation as universal as the independence and intelligence of the people, at the present than at any former period. The most that can be said of the latter proposition is, that some such division as it assumes between real and personal property, agriculture and trade, probably appeared originally between the two classes of members. This was the natural course as long as the duty of the House of Commons was confined to taxation. The original demarcation would probably continue visible as long as parliamentary attendance was considered as a burden rather than an honour. Historically, this and any similar distinction gradually fell into disuse soon after the 23d Henry VI. That statute required the knights of the shire to be actual knights, or such notable esquires and gentlemen (*generosi a nativitate*) as had estates sufficient to be knights, and by no means of the degree of yeomen. We find that a county member who had been actually elected, was set aside because he was not of gentle birth. A great change must be commencing before the possibility of the want of such a precaution could be suggested; and still more before the precaution, when taken, should not immediately succeed. The change may be assumed to have begun as far back as the 19th Edward II. when there were twenty-eight county members who appear not to have been knights. Of course the arrangements and very elements of society must have been still further broken up, before a manufacturer could have a chance of a successful nomination with the freeholders of a county court. It is but little that positive legislation upon these points either accelerates or retards. It can recall nothing; and, to be effectual, must continue to be in harmony with the wants and character of the times. This was abundantly proved in the failure of the statute of Henry V. the object of which was to compel members to be inhabitants of the places for which they served. The attempt fixes the era when the deviation from the old connection was attracting general attention. Its pertinacious vitality in the statute-book is a striking instance also of the extreme reluctance with which the English people, so far from anticipating needless innovations, have consented to affirm the innovations made by time itself. Prynne shows that Cornish names were formerly returned in the elections for Cornwall, and northern from the north. Clarendon opens his memoirs by stating the little communication which passed between different parts of the country, even with the metropolis, almost to his own time, except in the circuits of the lawyers. The names of the members for the counties were aristocratical, those for the boroughs plebeian. A few burgesses begin to be called esquires in the returns of Edward IV. By this time the House of Commons was becoming of sufficient importance to render parliamentary influence with a borough an object of ambition to the nobility and gentry of its neighbourhood. The character of the borough representation opened and extended itself accordingly. It soon embraced every description of person who had a claim to enter into public life. The lawyers, to whom attendance was probably less personally inconvenient than to others, appear to have come in earlier for more than their reasonable share. But this expansion and adaptation beyond its original purpose could alone have made the inequalities and anomalies of the borough representation tolerated so long. The citizens and burgesses, though always more numerous, seem to have felt their social inferiority, and for a long time to have continued more humble minded than the knights. Of the three hundred members, the average number from the 23d Edward I. to Henry VIII., a third or more were returned by the boroughs. During this long interval the sheriff exercised a discretion, to the use or frequently to the abuse of which the parliamentary existence, by prescription, of many unincorporated boroughs is to be ascribed. Boroughs by charter, even from mesne lords, and towns, whether the ancient or the actual demesne of the crown, made up the list. Many boroughs were originally inconsiderable places; and others imperceptibly decayed. This latter cause would take effect from the reign of Henry VIII., the date at which the elective franchise became constitutionally too valuable to be left, when it had been once enjoyed, to the mercy of the sheriff, or to be allowed by its possessors to drop into disuse. The royal prerogative of new creations which existed in the House of Lords, existed also over the borough compartment of the House of Commons. Elizabeth indulged herself in the plenary exercise of it in England, as freely as her successor did in Ireland; but, supposing that her subjects had ventured to remonstrate, she was too wise to have ventured, in return, on his indecent answer; "The more the merrier, the fewer the better cheer." The prerogative of adding to the boroughs, however, is one which could not last in an enlightened age. The same reasoning which pleads against a parliamentary or popular appointment of the peerage, presumes a parliamentary or popular appointment of the commons. It is not so surprising, that after the shaking up of the political opinions of the nation during the civil wars, one instance only of borough creation (that of Newark) should have occurred, as that Charles II. should have made the experiment even of one. Borough creations were the great reservoir whence the successive accessions to the numbers of the House of Commons had been supplied. Nevertheless, owing to the course pursued previously to the passing of the reform bill, the interests engaged in commerce and manufactures appear, notwithstanding the vast contemporary augmentation of their wealth, to have had less power in parliament, or at least less influence on legislation, than in an earlier age. The House of Commons in the first parliament of James I. consisted of 470 members. The last unreformed and the present reformed representation, reckoning the additions derived from the Scotch and Irish unions, are not much more numerous. They both give a total of 658. The difference between the two lies in the proportions in which these numbers are divided amongst the several classes of the people. It has been calculated that a hundred and fifty-four persons returned a majority of the former house. Counties formed the only large constituencies, whilst scarcely a single large town was represented. At present the franchise is compounded of a ratio of property and numbers. Mere nomination is destroyed; and, on analysing the numbers, it will be seen that the members for counties are 252, the members for towns and the universities 406. This question of proportion, though it has been assumed by critical writers, was evidently never before seriously thought of. The necessity of entering on such comparisons had not yet arrived. The means of securing the impartiality of the sheriff, and the independence of the electors, was formerly a more immediate and important point. It is impossible, from the gross partiality of the sheriffs (officers annually appointed by the crown), to reason upon the old returns. The freeholders of a county court were of course placed comparatively beyond their reach; yet sheriffs contrived to aid in the virtual disfranchisement even of counties. According to Prynne, it appears by the indentures that, as late as the 8th of Henry VI. the attorneys of a few great people could dictate or manage on occasion the representation of Yorkshire itself. In the meanwhile political information was spreading. Reformers of all kinds sallied forth. The decayed boroughs, and the consequent flagrant inequality of representation, became the subject of a criticism, founded on theories more or less correctly derived from the practice of earlier times. The very word representation provoked observation, and was in many instances in ridiculous contradiction with the fact. It appeared impossible that this could be what the constitution intended by the name. Even James I. was struck by it on his accession. The charge given by him to the sheriffs, on calling his first parliament, not to direct a writ to any ancient town, being so ruined that there were not such sufficient residents as to make a proper choice, comprehended a most desirable reform. The fault was in the mode which he proposed for carrying it into effect. The supposed prerogative was more than could be safely entrusted to a sheriff of James I. The system grew more unreasonable every day, both in reality and in appearance; and, to complete its indefensibleness, the stain of corruption gradually crept in, and deepened the offensive spectacle into a scandal and a nuisance. The reform bill has at last brought this long outstanding grievance to a satisfactory conclusion. The elective basis is so enlarged as to comprehend all the elements of sound national self-government, and the independence of the electors is amply secured against all danger but from themselves. The interference of the executive in elections may be more immediately dangerous to freedom; but a constitution undermined by corruption is infinitely more disgraceful to the parties who are guilty of it, and to their fellow-countrymen, who sit still in stupid connivance at their baseness. Lord Coke, mentioning the first case of bribery on record (in the 13th Elizabeth), denounces it "as poisoning the very fountain itself." The disease was communicated slowly. It is not yet a hundred years since it had reached the height and notoriety of being a public evil and a national dishonour. Clarendon, in his disdainful notice of the first ministerial intrigue in order to buy over a majority by bargaining and not by reasoning, leads us back to the origin and cause of all. He fastens on the government the first link of the chain, the length and burden of which naturally increased at every remove. Bolingbroke, the distinguished father of the modern Tories, lays the principal blame of it on Clifford. Members who could make money of their own votes, found it was worth while to pay for the votes of their constituents. Evelyn's *Memoirs* contain frequent ejaculations on the increasing expense and debauchery of elections, before and after the Revolution. In works of the date of Brown's *Estimate* and Chesterfield's *Letters*, it is noticed, for the first time, that the franchise of making laws for the English people was disposed of by boroughmongers under private pecuniary contract, or brought openly to market by burgesses and freemen, for the competition of public sale. The expense of elections, to say nothing of bribery, had become so ruinous, even in the earlier days of Burke, that in a speech on one of Mr Sawbridge's motions, he says, "the expense of the last election has been computed (and I am persuaded that it has not been overrated) at L.1,500,000—three shillings in the pound more than the land tax."

The antiquarian question of the origin and progress of the House of Commons is interesting, not merely as the title-deeds to English freedom, but as constituting an important chapter in the history of man and of society. It describes the germ and development of an institution which, in its extensive and permanent application, is an invention of modern times, and the most likely of all, not even excepting the steam-engine and the press, to influence the fortunes of the human race. In this view, the great consideration is not so much the steps by which its component parts were formed, as those by which its authority was obtained. There can be no doubt that the early summons to the commons was not honorary, but onerous. Long after the general right was perceived to be a national advantage, the particular exercise of it was felt to be an individual hardship. The real history of almost every people is in its exchequer. This is emphatically the case with England. Fiscal considerations lie at the bottom of its most celebrated institutions and enactments. Every body worth taxing was to be got at in some form or other. The right of arbitrary tallage upon towns was limited and invidious. It was abolished in the 25th Edward I. by the time that the new experiment was coming fairly into play. In the facilities which representation afforded to taxation, government soon found a compensation for the slight additional control and inconvenience which the co-optation of the commons into the legislature might by degrees and at times occasion. The yeomen owners of freehold lands were to give an account of their pecuniary capabilities in that character. Wherever property had grown up in other shapes, as in towns, it was also to be made amenable. Apparently when this was done by way of deputies, which was the ordinary mode in the estates and diets of the middle ages, no particular directions issued. There is not a word said in the writs concerning the qualifications of the electors, or the numbers to be elected, or the forms to be observed, either in counties or in boroughs. Two was the number fixed upon, probably to prevent subsequent confusion, either by prevarication, mistake, or sickness; and usage would soon turn the practice into law. Whilst taxation was the great object at stake, it was one in which all might equally be trusted for labouring to reduce the subsidy to the lowest point. The franchise in boroughs would easily devolve from the towns' people at large to a select council, when all that the voter got by insisting on the privilege, was a liability to pay his share towards the parliamentary wages of the member. The election struggles of a later age, indeed ever since the committee of which Serjeant Glanville was the chairman, have been vain efforts to undo the effect of these irregularities and encroachments. But the great objects of a national legislation and the spirit of freedom were of older date. Long before the actual existence of the commons as a third estate in parliament, the barons had extorted from their monarch, and had transcribed into the rude articles of Magna Charta, a principle and a feeling, before which the traditional longings after the laws of Edward the Confessor speedily expired. There was little left for the patriots of after times to add, but the necessary machinery of more adequate forms and institutions. Magna Charta seems to have been looked upon almost as a personal contract, which it was necessary to renew at the commencement of every reign, in order to make it binding upon successive sovereigns. The terms of its successive confirmations (Lord Coke reckons no less than thirty-two) fixed in the minds of men an inseparable connection between the grant of supplies and the redress of grievances. The House of Commons put forth at different periods the claim to its peculiar privileges and its general powers. As early as the reigns of Richard II. and Henry VI., we find it refusing to proceed in the public business without a sufficient answer. For a time the two houses voted separate and unequal aids. The first notice of the maxim that parliamentary aids must be granted by the commons and agreed to by the lords, appears in the 9th Henry IV. As the report expresses it, when both are of accord, the grant is to be signified to the king by the mouth of the speaker of the House of Commons. This is said to be "in manner and form accustomed, to the end that the lords and commons may have what they desire of the king." The strictness of this privilege can never have stood on any sufficient reason. It was unimportant whilst the two houses voted their subsidies singly, and bound each other to different amounts, which continued to be the course with the clergy in convocation to the last. It was still more indifferent which of the two began from the time that supplies were voted by them in concurrence, since either house, by the use of its negative, could protect itself. Restraints on the initiative are not worth contending for. The exclusive right of determining all questions connected with the elective franchise would have been a more equitable distinction. Upwards of a quarter of a century before the third estate was called to parliament, the barons had paid the subsidy demanded of them into the hands of four of their own order, with directions to expend it at their discretion for the benefit of the king and kingdom. It was not until after the Restoration that the House of Commons was provoked, by the scandals of the court of Charles II. to adopt the much more respectful form in use at present, for the control and appropria-

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tion of the national expenditure, although Clarendon declaims against it as an unheard of innovation. Of all their civil rights, immunity from taxation, except through parliament, has been that of which the English people were most tender, and which they first succeeded in thoroughly and irrevocably establishing. After the reign of Edward III. a few attempts, ill concealed under the soft words of loans and benevolences, are slight exceptions to the universal current of precedents. On this, admitted by Clarendon to be the clearest of all points, the Stuarts dragged the judges with them into the abyss. The patience and perseverance of the English people are equally signalized in the steady parliamentary resistance by which the account of ages was closed with the act of the 16th Charles I. c. 8, against the imposition of tonnage and poundage, without consent of parliament. It is the last act in the statute-book against arbitrary exactions of revenue. The right to participate equally in general legislation was obtained early, but slowly enforced. The 15th Edward II. had recognised the necessity of the concurrence of the commons to all measures whatever in the most positive terms. It is probable, however, that for some time afterwards, its assent for all purposes except taxation was little more than constructive. The commons, it is true, after the next reign, figure, by name at least, almost always in the enacting clauses; the laws being generally said to be made by the king, with the assent of the lords, at their request. At this period, however, the king, by diminutions and additions to a petition, often so completely changed its nature, as to become himself the real legislator on its contents. They consequently insisted, in the 2d Henry V. "considering they had ever been as well assenters as petitioners," that without their assent it should be no statute. The abuse was only put an end to in the reign of Henry VI. by the slight variation of drawing up the bills in their present form. There is only one instance mentioned during the tyranny of Henry VIII. of the rejection of a bill supported by the crown. The commons found courage on several occasions to resist the measures of his children. The year 9 Henry IV. above referred to, is also remarkable for the first assertion in behalf of freedom of speech in parliament, by declaring that the king is to take no notice of what passes there. This impunity is confined, however, to the locality of the speech so spoken. A publication of it by the press or otherwise is responsible to the ordinary law. The earliest definition of privilege on arrest is in Larke's case, in 8 Henry VI. The case of Storie in the 4th Edward VI. is the first commitment which has been recorded of one of their own body for contempt. In proportion as the House of Commons became gradually more and more mixed up with the general affairs of state, the possession of these powers and privileges rose in importance, as being essential to its independence. Mere assurances of this or that immunity are of no avail, unless the means of realizing them also exist. The necessity to which Sir Thomas More was obliged to yield, of retiring into private life, in order to escape the displeasure of Henry VII., on account of a speech in the House of Commons, shows that the season for a valid parliamentary opposition had not yet arrived. In the attack upon the five members in the house itself, Charles I. outheroded himself. On other occasions, he had lain in wait for the dissolution of parliament, which was his usual signal for resuming more open hostilities against the liberties of his people. As soon as the speaker's mace had been disenchanted of its protecting power, the royal warrant was wont to go forth against the most popular of the late members by whom his illegal designs had been principally thwarted. The law and the fact, however, improved together. Both houses have long been in possession of whatever powers can be necessary for the performance of their public duties. Popular members are as safe after as during sessions. Nobody dreams of intimidation. Parliamentary corruption has not merely declined; it has almost disappeared. If a comparison between the pensioners and placemen of ancient parliaments, with the modest list of officers of the crown sitting there at present, be satisfactory, what ought to be felt at the contrast between the unblushing bribery of Walpole's administration and the purity of modern governments? The compulsory economy introduced into the treasury has co-operated, with other causes, of which the chief is public opinion raised under the sanction of the middle classes, to elevate the standard of public morals amongst public men. The boundary which separates legitimate and undue influence, is that at which practical politicians no less than theoretical reasoners have arrived at last. As corruption began at the top, it has first ceased there. Whatever remained to be done in improving the public spirit of the elected, as well as of the electors, it is the direct tendency of the reform bill to accomplish. The elective franchise is now thoroughly identified with the nation, and is made, in the eyes both of those who choose and those who are chosen, more visibly and entirely a public trust. The destruction of the nomination boroughs leaves no pretence for the open constituencies which persevere in converting the trust into a sordid personal advantage. The parts which unfortunately appear to continue tainted are as yet inconsiderable. Unless they yield to the alteratives by which the whole body politic has been renewed and strengthened, they must be cut out. History holds out no hope that the inconsistency of incorrupt representatives and of corrupt electors can continue long.

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The supposition of a legislature consisting of three coordinate authorities, does not imply a defined line or logical division to which they must each conform, and which every body can distinguish; on one side of which, the concurrence of the several parts must degenerate into mere dependence; whilst, on the other, their separation must form into impracticable opposition. The experience, however, of all mixed governments, more especially a comparison of the case of England with that of countries subject to the simple forms, establishes the fact that it is not a mere fiction, concealing under nominal distinctions the real servility of the inferior in their subjection to the superior members of the supposed partnership. It is evident that a sort of adjustment does practically take place, sufficient to produce a palpable effect. The nature and temper of a particular society may easily make such a constitution impracticable. But, under fortunate circumstances, it in a great measure accomplishes the ends which it is its professed object to perform. The problem assumes the natural inclination of its respective parts to press unduly on each other. In tracing a constitution which has been formed by time, and has endured through ages, the tendency of the several biases must be expected to be more apparent, now one way, now another, than in a government of entirely new construction. Encroachments at different periods are more likely to take place, from a recurrence to former usages on one side, or from a spirit of re-action to them on the other, in constitutions which have grown up, like those of England and ancient Rome, by the amendments of centuries, than in mechanical contrivances, like the government of Lycurgus and that of America, modelled from the beginning and at once, on an express design. Accordingly, English history presents examples of each branch of the legislature in its turn assuming a legislative power. The king has issued his proclamations to create, not to promulgate law, under the pretence of state expediency. An irregular exercise of the equivalent power of suspending or dispensing with the law, in other words, a claim to untie by himself the knot which the entire legislature had tied, had prevailed so long, that even at the Revolution it was only partially denounced. Ordinances authorized by both houses, whether for the militia or otherwise, are equally indefensible. The same is the case *a fortiori* with resolutions by either house singly against putting in execution such laws as happen to be unacceptable to it, but which the other branches of the legislature are not willing to repeal. Notwithstanding a most unguarded admission by Mr Justice Gould to the contrary, in the conflicting decisions which arose out of Wilkes's case, there can be no doubt but that the doctrine of Lord Mansfield is correct. Speaking of declarations of law made by either house of parliament, he observed, that he never thought himself bound in his judicial capacity to honour them with the least regard. The vote of the commons in 1648, that their single enactment was law, called forth on the Restoration the statute of 13 Charles II. It subjects to the penalties of *præmunire*, the advised affirmation that both or either of the houses of parliament have any legislative authority without the king. The unconstitutional attempts of both houses, especially of the lords, to extend their jurisdiction as courts of justice, brings us properly to the next consideration.

Judicial power.

The necessity of separating the judicial from both the legislative and the executive power, and of vesting it in independent tribunals, is now universally admitted. But it is a necessity which antiquity never perceived; and it was in direct opposition to the letter and the spirit of the feudal system. Therefore the successive generations which moulded the English constitution into shape, may be excused for having learned it but slowly and by experience. English history providentially is stained with fewer judicial iniquities, which are the greatest of all crimes, than that of almost any other country. But a failure of justice is the worst feature of the long period comprehended in the lines of Plantagenet and Tudor. Perhaps the greater part of the deficiency is to be attributed to the imperfect division of these powers, especially of the executive and judicial. Lord Clarendon has left a picture, sketched as late as the middle of the reign of Charles I., of what may be expected from a legislature, a court of justice, and a board of administration, all in one. Officers of the crown became " a court of law to determine civil right, and a court of revenue to enrich the treasury; the council table by proclamations enjoining to the people that which was not enjoined by the laws, and prohibiting that which was not prohibited; and the star-chamber, which consisted of the same persons in different rooms, censuring the breach and disobedience of those proclamations by very great fines, imprisonments, and corporal severities; so that any disrespect to any acts of state, or to the persons of statesmen, was in no time more penal, and the foundations of right never more in danger to be destroyed." The supreme courts at Westminster were originally derived out of the royal court or *aula regis*, which consisted of the great household or personal officers and the barons. They were intended to dispatch the ordinary judicial business, especially during the absence of the household and personal officers in attendance on the king, or when the barony might not be assembled. The authority of these derivative courts, whatever might be the case with the *aula regis* as far as concerned the barons, was not in the eye of the law inherent. It was supposed to be delegated to them by the king, as the fountain of justice to his subjects. The judicial power of parliament, however, was not displaced, nor meant to be so, by these auxiliary institutions. Fleta, writing in the reign of Edward I. treats it as still the high court of justice, " where doubtful cases of judgments are resolved." There can be no doubt but that annual parliaments were first demanded, and their intermission felt to be a much more serious grievance on account of their judicial than of their legislative capacity. It is evident, from the state of the early statute-book, that the meeting of many a parliament might have been saved had they met only for the purpose of legislation. There is a memorable order of 18 Edward I., by which petitioners to parliament are apportioned to the several subordinate courts of justice, both for their own dispatch, and to enable parliament to attend to public business. If the matter happened to be so great or of such grace that these courts could not end it, the chancellor and chief ministers were with their own hands to bring it before the king and his council. Coke observes, that wherever the king and council are mentioned judicially, it is to be interpreted to mean the House of Lords. The celebrated treason statute, 25 Edward III. closes its enumeration of the treasons specified therein with the express reservation of " other like cases of treason which may happen in time to come." In which case " the judge shall tarry without going to judgment of the treason till the cause be showed and declared before the king and his parliament, whether it ought to be judged treason or other felony." The reservation, however inconsistent with the right of a people that the law shall be defined beforehand, so that they may know what to avoid, and under what penalties, is plainly a reservation of judicial and not of legislative power. In fact, this parliamentary superintendence is recorded, on the authority of Chief Justice Thorpe, to have been at that time the common course in other cases as well as treason. He stated, in the 40th Edward III. " that he and Sir Hugh Green went together to the parliament, when there were present at least twenty-four bishops and earls, and asked the opinion of those who had been the makers of the late statute of jeofail, concerning the alteration of a record." " At another time," the same judge says, " we were commanded by the council, that when any case of doubt should happen, we should not go to judgment without good advice; therefore," adds he, in the case then before the court, " go to the parliament, and as they will have us do we will, otherwise not." The danger from this anomalous tribunal would have been increased a thousand fold, if the lords had succeeded in the unwarrantable claim which they set up in 11 Richard II. to a law of parliament differing from the civil and the common law. The extension of this irregular claim by Coke to the privileges of the lower house was more, certainly, than the imperious barons of Richard II. ever contemplated by their mutinous declaration. But it is still more unwarrantable, and more surprising, that Burke should have renewed the doctrine of a parliamentary supremacy, in judicial proceedings before parliament, over the rules of ordinary law. As the penalty of this grievous error, his admirable Report on the proceedings against Warren Hastings remains comparatively unknown.

The share which the House of Commons took in this judicial jurisdiction was, if any, very inconsiderable. Thorpe in the above passage uses the word parliament, but mentions only earls and barons. The ordinance 6 Henry IV., which has provoked so much legal spleen, from its directing that no apprentice or other man of the law should be elected a knight of the shire, took its hint from a previous one in the reign of Edward III. against lawyers practising in the king's court. They were accused of putting forward, as public petitions of the commons, matters which concerned only their own clients. Notwithstanding the expression client, the ground of disqualification here assigned relates probably to what was formally legislative, and not judicial business, something like the private bills of the present day. From the course of the constitution, as well as on their own disclaimer, Mr Hallam considers that the intermeddling at all in judicature by the commons upon the petitions addressed to them, was pure usurpation. He suggests that their intrusion may probably account for the disuse into which, from the time of Henry IV. the lords allowed their appellate authority to fall. It is very difficult to make out the steps by which they could have claimed the right in question. But there is some difficulty in conceiving that the influence of the House of Commons was so commanding at the period in question as the alternative supposition would imply. Could they be strong enough to make good a mere encroachment of this sort, and leave a competitor like the House of Lords no other method of resisting their invasion of its ancient right than by also abandoning it altogether? Writs of error were resumed by the lords about the accession of James I., renouncing all claim to any original jurisdiction in judicial causes. This is surely anomaly enough. All pretence for the other had disappeared in the equality of persons, in the uniform supremacy of the law, and in the acknowledged excellence of the ordinary tribunals. Notwithstanding this disclaimer, the extent to which the English legislature, under circumstances more or less excusable, perplexes itself with questions properly belonging to courts of justice, is subject to serious objections. It nowhere appears to such disadvantage as in bills of attainder, of pains and penalties, and divorce bills, which are all proceedings of a judicial nature applied to a case of *ex post facto* law. In judicial inquiries, carried on as such by either house, its numbers, partialities, habits, and the intrinsic difference between legislative and judicial considerations, make it impossible to convert a legislative assembly into a satisfactory court of justice. This truth has been frequently, and is still, occasionally verified. In its character of a court of ultimate appeal, the House of Lords escapes the disgrace which must otherwise have been heaped upon it long ago, by retaining the jurisdiction only in name, whilst the jurisdiction is in fact abandoned to its legal members. There is more to be said for so peculiar an exception as that of an impeachment. But later precedents, as in the instance of Warren Hastings and Lord Melville, do not warrant the expectation that an impeachment, even before such a body, can easily become an efficient instrument of justice. The only judicial matters which can be brought before the House of Commons are proceedings for contempts. Hurried on under great excitement before the whole house, they are exposed in an aggravated shape to whatever risk proverbially disqualifies an individual from being a judge in his own cause. It is only in comparison with what is recorded of the trial of disputed elections by the house itself, that election committees have acquired a conditional reputation. Committees on private bills are frequently legislative only in form, whilst they are in reality judicial inquests. They consider themselves above even the forms of justice. Nothing is more common than for members to oblige their friends, by stepping in to divide upon the merits of a case, where they have never heard a syllable of either the evidence or the discussion. It is a singular instance of the force of habit, and of the barrier raised by technical distinctions, that this is done by persons who would act nevertheless with perfect honour upon a jury.

In a simple state of society the judicial and executive authorities are always found united. Eastern kings administered justice at the gate; St Louis under the oak. A confusion between these authorities is therefore, under all governments, in the natural course of things a more probable event. The original theory of the English constitution, as far as theory can be predicated of its rude provisions, saw no incongruity between the duties. The traces of an entirely opposite presumption are still amongst the minor embarrassments of at least the language of the law. The administration of justice in the name of the king was formerly more than an honorary prerogative. It was a feudal truth and necessity. It is now a fiction which can only mislead both kings and people. Blackstone says, that when the law calls the king the fountain of justice, it does not mean that he is the author of it, but the distributor. Yet there are many things contrary to this distinction, and the contradictions show most strongly the mischief of these metaphorical compliments. The payment of fees on original writs, the unjust rules in the exchequer in behalf of the prerogative, the flagrant fines in the olden time as the only means of obtaining common justice, presuppose that the king was so far its author that he could only be asked to grant it upon his own terms. Judicial extortions became less frequent after Magna Charta; but they prove the grievous necessity which existed for its assurance that the subject should have remedial justice, "freely without sale, fully without any denial, and speedily without delay." A tax on justice is one of the worst sources of royal revenue, under whatever title it be imposed. At the present day the propriety of completely separating executive and judicial duties is the tritest truism. It is next to impossible that a sovereign should have the leisure, the attainment, or, in the most important cases, the impartiality, to administer justice in his own person. The guilt of tampering or of intimidation addressed to the judges, to whom the king has on the part of society committed his judicial trust, is a heinous offence in the meanest subject. When it proceeds from the king it is aggravated a thousand fold. But it is not enough that the hands of justice should be pure. Their purity should be beyond suspicion. For this purpose the independence of the bench ought to be maintained above all possibility of fear or favour. Perhaps there is no better evidence of what had long been only tradition concerning the personal attendance of the king in his courts of justice, and on the limits within which he was confined, than is contained in the case of jurisdiction of the House of Peers in the year 1666. It is there said, that "when the king attends in the House of Lords in his judicial capacity, he sits but as chief justice, doing nothing singly, but by plurality of opinions, as when the kings would in person sit in the king's bench, which they have in former time done, where all is said to be *coram rege*, though now he never come there; and in our memory King James hath sate in the star-chamber." It is natural that the king's presence should be last seen in the courts, which were not made unintelligible to common understandings by the forms of the common law, and which, by retaining the longest the name and the character of his council, seemed to keep the nearest to his person. Serjeant, when elected speaker in 1640, tells Charles I. "My disabilities are best known to myself; and to your majesty, I suppose, not altogether unknown; before whom, in the course of my practice and profession, it hath been your goodness towards the meanest of your subjects divers times to do me the honour and favour to appear and bear a part as an ordinary pleader." So little did the Plantagenet generation know what they ought to have prayed for on this subject, that in a list of very bold articles presented by parliament, to which Henry IV. consented in the eighth year of his reign, there is found the following request. It was prayed his majesty, that, "considering the wise government of other Christian princes, and conforming himself thereto, he would assign two days in the week for petitions, it being an honourable and necessary thing that his lieges who desired to petition him should be heard." James I. had a great longing to exhibit every phasis of his learning to his subjects. After having been told in Wraynham's case by the judges, *cessat regnare qui cessat judicare*, it is not surprising that he should think the opinion of Lord Coke, that kings of England were incapacitated from the exercise of any judicial functions, little short of treason. Nothing, however, is more fully settled than that, as on one hand, the House of Lords, the Privy Council, and the ordinary tribunals of the common law, derive all their judicial authority in the first instance from the crown; so, on the other, whatever judicial authority the king originally possessed, it was possessed as in a reservoir, and has since all passed out of him into the appointed channels of his courts.

Direct interference on the part of the crown with the integrity of the judges was unfortunately not peculiar to the Stuarts; but it ended with them. It was carried by them also to such extravagant and unheard of lengths, as to throw all previous outrages of this description into the shade. The ignominy of the imputation has rested therefore principally on their name. Elizabeth had the sense to respect the honour of the interpreters of her laws; so that Coke felt what he called the taking of auricular confessions by James to be a novelty and a disgrace. The course, however, of the whole judicial history of England teaches a great lesson: the extreme difficulty of maintaining freedom with dependent judges. The struggle began at Nottingham, with the treasonable surrender of the infant constitution of their country by Tresilian and Belknap, in their discretionary expositions of law to Richard II. The impunity of intervening centuries tempted the colleagues of Finch and Crawley to believe that, supported by a sovereign at least as arbitrary, they might in their day set parliament at defiance. Although their virtue often failed, yet, in the main, the judges of the supreme courts of Westminster did their duty beyond what could have been expected. Fortunately for their characters, special commissions, composed chiefly of courtiers, were issued on most occasions of jealousy and alarm. In consequence, they seem to have kept their ground in the confidence of the public much better than the subordinate magistrates, who were subject, but in a less degree, to the same influence. These latter never gave much satisfaction. The ancient conservators of the peace, instead of continuing to be elected by the freeholders, were turned, in the first year of Edward III. into nominees of the crown. The necessity of suppressing the malefactors, who appear in those days to have been at times encouraged by members of the nobility, could not prevent the justices so appointed, on the extension of their jurisdiction, from becoming speedily unpopular. A petition from the House of Commons, in the 11th Richard II., declares that "every freeman in the land would be in bondage to these justices." Even in the retrograde years between Henry VI. and VIII., the difference between the independent tribunal of a jury, and that of perpetual officers connected with the executive, was well established. The right that criminal proceedings should follow the course of indictment and of the common law, is repeatedly and earnestly urged. Juries had so far begun to do their duty, that the fiscal purposes of Henry VII. could only be carried into effect by enabling these creatures of his power, removeable at his pleasure, to try all offences except treason and felony by themselves. The restoration of a jury to its pristine rights was one of the measures by which Henry VIII. won, on his accession, the popularity which he afterwards so cruelly abused. This affectation of a return to the old constitutional character of the English courts of justice, was soon overthrown by terrible innovations, like the creation of the president and council of the north, and of the Welsh marches. The worst part of these novelties consisted in their in reality placing the judicial and executive authority in the same hands. What could the subject expect from a tribunal of which Wentworth was the president? Mr Hallam says that these and other irregular tribunals, when abolished by 16 Charles I., had usurped so extensive a cognizance as to deprive one third of England of the privileges of the common law. It was nevertheless reserved for the high churchmen of Charles II. in the year 1664, to return to the charge. Legislating against what they unjustly called seditious conventicles, they ventured to arm a single justice (it is necessary to remember only what were the dependent justices of those days) with the power of inflicting seven years transportation on a third conviction of the offence of worshipping God contrary to act of parliament.

The objection applies still more strongly to the original authority of the sheriff. The shrievalty was generally sold by the Norman kings, and was an office of great emolument, and still greater influence. The coroner, with his limited inquest of criminal police, was left to popular election. But the sheriff, from the conquest downwards, except during the sixteen years which intervened from the 28th Edward I. to the 9th Edward II., was nothing but the annually nominated servant of the crown. Great judicial authority was intertwined with his civil superintendence over his county; the more so, because the law has never sufficiently distinguished between acts which are judicial, and acts which are ministerial only. Although in the hundred and the county, as well as in the baronial court (not being courts of record), the freeholders were the real judges, both of law and of fact, the sheriff's authority was the subject of great alarm. The principal sources of this jurisdiction were by degrees turned into other channels. Criminal pleas were taken from him entirely as far back as Magna Charta. The complaint upon which that clause was founded had only sought that he should be restrained from hearing them except when assisted by the coroner. The confidence felt in the popular presence of that officer for decompounding and breaking up this dangerous identity of powers, appears by several other writs in Rymer. The justices-in-eyre, not being the same always as the judges of Westminster, were probably often but partial improvements on the local administration of the sheriff. Their circuits, however, facilitated the transfer of most of the civil as well as the whole criminal business into a more strictly and purely judicial court. The civil cases still cognizable in the county court, in which the sheriff is both presiding officer and executioner of justice, are the inconsiderable and almost obsolete remains of former usage.

From this brief review, it appears that formerly the judicial power was often placed in the same hands with the legislative and the executive. This probably never took place without the people suffering severely from it. The small territorial jurisdictions, civil or criminal, must have been the worst of all. The existence of other checks at present, and the vigilant rapidity with which public opinion keeps hovering over and bearing down upon all official misconduct, may blind us as to the importance of the principle itself. A hazard, of which the only actual mischief is in the precedent, may seem not too much to incur for the convenience of this or that exception. At the same time, no nation is wise which in such a case presumes too far upon its security. A judge, when member of the legislature or of the cabinet, is in a position which ought to create, both with himself and with the people, a degree of watchfulness, not to say jealousy, far beyond the case of other men. It is to be remarked, that the greatest of all exceptions which occurs in this respect in English practice, that of the Lord Chancellor, occurs in the very instance where the existence of the judge depends on the casualties of the ministry of which he is a leading member. An examination of the judicial removals during the Stuarts shows the extent to which the hopes and fears of the bench were constantly played with. It was a system, and not an accident. Nothing short of the 13th William III. could have put it down. That statute altered the patents of the common law judges, from patents during the king's pleasure, to patents during their own good behaviour. The little that was left to be done, was done at the accession of George III. This last amendment consisted in excepting their commissions from the fate of all other crown appointments, that of being vacated on its demise. It was a very prudent waiver of the little remnant of arbitrary power which, strange to say, had in the interval been misused. But the waiver could of necessity be made by any actual sovereign, solely at the expense of his successor. If a stop had been put to the analogous suspicions connected with the promotions of judges and the translations of bishops, it would have obviated an evil of more frequent recurrence. On considering the elements of the character and of the happiness of the nation, the English people are perhaps not more indebted to their participation in legislation by means of the House of Commons, than to their share in the administration of justice in the capacity of jurors. Not only has the executive been kept at bay by their interposition, for the legal verification of the fact at issue, but the legislature has received more than one useful warning from their collateral influence on the law itself. For both these purposes it was indispensable that intimidation should be removed from a juror as thoroughly as corruption; and that offences imputed to him in the discharge of his duty should be investigated and punished as cautiously, as reverently, and before as impartial, if not as solemn a tribunal, as similar offences imputed to a judge. The day when, in Bushell's case, the court relinquished the pretension of fining or imprisoning a jury for its verdict, ought to be as memorable as any in the annals of the victories of justice. It heralded in, and was in no degree less important than, the day which made it impossible that any successor of Pemberton (for even the chief-justice who tried Russell had paid too much respect to freedom) should be arbitrarily displaced. In this point of view the dissatisfaction expressed by Jefferson with the corresponding rule in the constitution of the United States, that the judges are irremoveable, except by a resolution of two thirds of congress, is very surprising. The exception would seem amply sufficient to secure the legislature the necessary discretionary control. Considering the position occupied by the ordinary courts of justice in the United States and in England, it is impossible that they can make any serious encroachment on the other departments of the state, without a degree of negligence or connivance on the part of the legislature utterly inconceivable. The cry against judge-made law, on the ground of its being an unwarranted encroachment, appears also, to the extent to which the common law courts have carried their incidental legislation, to be quite unfounded; and most of all in England, where the common-law judges are much more justly liable to the inconsistent accusation of standing too stoutly upon the letter and strictness of the law, and of having brought on the necessity of an equitable jurisdiction and of irregular tribunals, from their narrow adherence to precedents and forms. They are not answerable for the main defects of the English system, whether in the body of the law itself, in the centralization of the metropolitan courts, or in the inadequacy of the local jurisdictions.

Executive power.

A government, where in point of form the legislative and judicial authority appears to emanate from the crown, is certain to have placed its executive power solely in the king. Long after the two former authorities have succeeded in gradually emancipating themselves from every thing but the antiquarian recollection of their original subordination, the latter arrangement will in all probability retain its pristine vigour. This is the consequence of the substantial advantages which belong to a single and permanent executive. Such, at least, has been the course pursued in England. The founders of the republic of the United States, from their near observations upon the French Directory, and from their personal experience of the disunion of executive committees during the war of independence, admitted the propriety of placing the necessary powers of the general administration in the hands of a single individual. The name, whether king or president, is hardly worth discussing. The great questions are, the mode by which this supreme magistrate shall be appointed, and the powers with which he shall be invested. In comparing with this view the English and the American systems, the principal difference between them is in the mode by which the executive is appointed, and not in the amount or nature of its powers. In their jealousy of the concentrating effect of power, the Americans have subjected all the members of congress, the senate as well as the house of representatives, and the office of president equally with the senate, to the principle of rotation; only differing in the degree of rapidity with which the elective wheel in the several cases performs its circle. By this specific the evil tendencies of political power are supposed to be reduced within manageable limits. Impartial spectators, on comparing the risks of hereditary descent as experienced in England, with the risks already manifested in the quadriennial presidential elections of America, may perhaps be disposed to decide in favour of an hereditary parliamentary title, with reference to the actual passions and prospects of society. A four years' lease of the president's chair may be too exciting a prize to be safely left to popular competition. Besides, the very character and abilities most likely to be admired, are those on which the temptations of such an elevation must act with the greatest force. It is one of the advantages of the English system, that whilst the doctrine of descent greatly limits the probability of dangerous talents in a sovereign, the mechanism of the constitution is so well arranged and understood as to do its work without them. The powers vested in the royal executive are not extreme; for they are nearly the same as those which it has been found necessary to maintain in the United States, notwithstanding all the advantages of a new country.

Under an ancient but progressive government, the executive authorities of the chief magistrate, like all the other authorities of the state, must be capable of being considered in three different points of view. These are, the historical, the actual, and the philosophical. Its constitutional history will vary, both in the facts which it exemplifies, and in the reasoning by which it is explained, at different periods. The correct legal description of it at any given moment, for instance the present, can represent at most only the law and practice of the age. The philosophical conclusion, how far it ought to extend in reason, may be, and probably will be, only obscurely signified in either of those inquiries. Mr Allen, in his inquiry into the rise and growth of the royal prerogative in England, and Mr Hallam, in different parts of his constitutional history, have left little to be added upon the first division. Mr Bentham, in his treatise upon legislation, has generalized upon the last. The legal exposition of the second is all that Blackstone properly undertook. Nothing certainly can be more absurd than the language which he has copied, in order to express the paradoxical fictions of the supposed attributes of sovereignty, perfection and perpetuity. The parliament which consented to describe the forfeiture of the crown by James II., under the euphonism of an abdication, proceeded in the selection of the word on many precedents. Their ancestors, at every compromise with royalty, had demonstrated much indifference to words, provided that the end and consummation were substantially achieved. In English constitutional law, an unlimited and almost oriental deification of expression is found alongside of rights strictly limited and specifically defined. The Plantagenets, however, were much more cautious than the Tudors in bringing this inconsistency to the test of a collision. Unluckily for the Stuarts, they were mystified by the welcome homage of servile civilians and meddling churchmen. By forcing on the solution of the problem, they learned too late, that from the fact of the prerogative being incorporated with the law, whatever was not found there could not possibly be within it. Even Locke's definition of prerogative, which Blackstone has thought fit to praise, is too liberal, not only for the rights of reason, but for the rule of law. "The discretionary power of acting for the public good" does not extend to all cases "where the positive laws are silent;" but to such points only as the constitution has expressly reserved for this discretion. Otherwise we come to the intermediate inherent power on which James I., in his Flowers of Grace, claimed for royal proclamations the force of temporary laws. The proper course on such extraordinary occasions is for ministers to act on their responsibility, and trust to parliament for an indemnity. The Stuarts were doomed to make the additional discovery that, among prerogatives strictly legal, there were some, both prerogatives of authority and prerogatives of revenue, which, being false in principle and mischievous in effect, the public had become sufficiently intelligent and powerful to recall. Our early kings, in the insidious reservations (*salvo jure coronæ nostræ*) by which they narrowed many of their most popular concessions, had succeeded in a great measure in rendering that part of the constitution unimproveable and fixed. This was the course, before notions of an abstract *jus regium* by consent of nations, or the doctrine of a native immortality in the prerogative, which acts of parliament even could not reach, had been yet imported into courts of law. A struggle which could only be kept up by these new and desperate assertions, was evidently near its close. These novelties were in part the penalties of the Reformation, at least as applied to England. Henry VIII. obtained for the crown a new prerogative on that occasion. It was a more dangerous one than perhaps all before it, in consequence of the greatness of the subject which it concerned. The act of supremacy was the corner stone of the high commission court. Mr Hallam truly observes, that "the real aim of the clergy, in enormously enhancing the pretensions of the crown, was to gain its sanction for their own." They played into each other's hands. If, as Mr Hallam affirms, the nation might be considered, up to 1640, as having been, "in regard to spiritual dominion, a great loser by the Reformation," it would have lost every thing in regard to the crown, had civil liberty depended on the loyal sophistries of the church. The apparent strength of the executive on the breaking out of the civil wars, presented so formidable an aspect, as to deceive even Strafford not only into a desertion of the cause of the people, but into the adoption of the language and sentiments of Laud. From the example of former times, and from the external superiority which necessarily surrounds the throne, he egregiously miscalculated the means of the two parties who were then about to decide this battle by an appeal to arms. It is scarcely less surprising, after its result, to find political judges like Jefferies so intoxicated by the saturnalia of the Restoration, as to continue to hazard these and similar insane *dicta*, down to the very eve of the Revolution. On that event the nation carried the principle of the exclusion bill by acclamation. The exclusion bill was looked upon, from the time that it was first mooted, as the extreme case. It was among the principal argumentative advantages of the Revolution, that it put an end to all discussions founded upon the supposition of inviolable prerogatives, then and for ever.

It is perhaps not too much to say that the *direct* prerogatives, in respect of authority, which were objectionable, are all either abolished, or, in case the law of England allowed of desuetude, are obsolete. Some few *incidental* ones remain, which appear to be in the course of removal; since recent legislation has happily shown a desire to look towards a reformation of the law. It is unfortunate that the direct prerogative, which is on the face of it the most revolting, nevertheless, from its having so long principally supplied the king's service with seamen, demands, in the immediate modification of it, considerable caution. Marine impressment, it must be remembered, came in, however, upon no supposed necessity of this nature. It is the remnant only of a doctrine and a practice which at one time included soldiers, and many classes of civilians. Like most other prerogatives, it was abused under Charles I. for the purpose of extortion. Several of the common people who refused loans are said to have been pressed into the navy. There has fortunately been such little demand for prerogative learning since the great argument of ship-money, that the judgment of Sir M. Foster in Broadfoot's case, in the year 1743, in support of the legality of impressment, was wanted to recall the attention of English lawyers to the several conditions which the law requires as evidence of a subsisting prerogative. The debates on the alien act revived these discussions for a season. The lawyer and the statesman look at questions of this kind from different points of view. The first regards what is; the second, what ought to be. For whether the particular powers are wanted, and where they should be placed, are further questions. In case these questions are settled in the affirmative, it is unwise, by division, rotation, or a multiplicity of checks, to reduce their efficiency below a certain point. Society loses more than it gains by such expedients, as often as necessary powers are thus incapacitated for the due performance of their functions. This was frequently attempted in ancient times. On the other hand, governments cannot be too cautious against the abuses which constitute the provocations to such restraints. Unjust interpositions of the *nolle prosequi*, and of pardon by the crown, gave popularity to the appeal of murder. Lord Holt, looking back rather than around him, called the anomaly "a noble remedy." Several petitions were vehemently urged by the commons of former days against the generous prerogative of mercy. The degradation by James I. of the prerogative of honours, by bartering them, for the first time in English history, for money, and the subjecting the peerage by Queen Anne to the personal ambition of a minister, have the same tendency. They bring the prerogative itself, as well as the subjects of it, into disrepute. The prerogative of making peace and war was tarnished by the base negotiations of Charles II. It was damaged later still, when Chatham himself was not able to withstand the electoral prejudices of his sovereign in behalf of a campaign in Germany. The observation may be extended through every department of administration. It applies especially to the formation and the government of so jealous and delicate an engine as that of a standing army. The moderation which the executive had displayed in the exercise of more qualified powers, could alone have introduced into and kept in the mutiny act the clause by which courts-martial are enabled to punish mutiny and desertion with death. It was inserted for the first time in 1718; and it was only carried at the time by small majorities. Of the impolicy of creating an atom of waste power there can be no dispute. But if the power is really wanted, they are sorry horsemen who are obliged to keep the strength and courage of their horse permanently below his work, as their only means of riding him. On the supposition that the powers are fitting powers for the executive magistrate to possess, the appropriate remedy is to apply ministerial responsibility to such cases, and to take care that the responsibility shall be a reality and not a name. The healthiness and *vis medicatrix* of the general system must do the rest.

The prerogatives of revenue depend on a different class of considerations. The financial purchase of tenure by chivalry from Charles II. and the subsequent arrangements entered into on granting successive civil lists, have not gone so far towards completely sweeping out the holes and corners of the exchequer as might have been wished. The last fibres of the barbarous fiscal pretensions which flourished there in former days have still to be rooted up. The national revenue, properly considered, consists of the portion of his property which each subject contributes to the state, in order to secure the remainder. That being the just principle, its demands should be limited in amount to what is necessary for the proposed object, instead of setting a fiscal net to catch an irregular and indefinite number of certain matters. Further, by an accurate calculation and repartition, the necessary taxation ought to be equally borne, in respect of their means, by all the king's subjects, instead of falling upon particular individuals on the happening of particular contingencies. In its original state most of the ordinary or prerogative revenue raised the least possible sum with the greatest possible inequality and inconvenience. The greater part of what remains is only remarkable for its picturesque absurdity. There is, however, one terrible exception, far too monstrous to be left for mitigation to the humanity of the treasury. Nothing can be worse than the wholesale forfeitures and confiscations which still sweep in the train of our criminal proceedings. In spite of the praises bestowed by Blackstone on Mr Yorke's essay in defence of the law of forfeiture, and although the people owe the 25th Edward III., which has been called the magna charta of treason, almost solely to a squabble between the king and his grantees the barons, for their several portions of the spoil, according as the late owner had been found guilty of treason or of felony, it is impossible that the reason and humanity of a great country can much longer permit cruel iniquity, abandoned by the most civilized part of Europe, to be justified upon antiquarian learning or by metaphysical refinements.

Blackstone's declaration at the commencement of his chapter on prerogative, that the powers which are vested in the crown by the laws, are necessary for the purpose of society, may be thought even now, if their whole detail is minutely examined into, to go something beyond the truth. The exceptions, however, can be in practice of no great consequence. The most obscure member of parliament would have nothing to do at the present day but to attack any indefensible exception, by a motion for its repeal. From the era that a general control over the government passed into the House of Commons, influence has so much superseded force, that questions of pure prerogative have lost much of their importance. According to present usage, any transaction arising out of its exercise, if it is at all interesting or doubtful, must be brought sooner or later before the House of Commons. The difference in the three modes of proceeding, between which alone a minister has to choose, comes to little more than the option at which of its stages the transaction shall be brought there. This will depend on circumstances. It may be a case in which there is no pretence of a prerogative, as on a suspension of the habeas corpus act. Or the principle of a prerogative may be pretended; but it may be suggested that the means for carrying it into effect are defective, as was suggested in the alien act. If there be time to apply to parliament to strengthen the executive, a prudent adviser would recommend, especially wherever a continuous measure is required, of necessity, on the first of these supposed occasions, but on both of them would he equally recommend, that the authority of parliament should be called in. In case a temporary emergency arises, more especially one which will not wait for parliament, as in the instance of the embargo laid by proclamation upon vessels laden with wheat in the scarcity of 1766, every administration is bound to take the responsibility of the measures demanded by the emergency; and parliament is bound to indemnify the authors of them for venturing upon a discretionary rigour beyond the letter of every day's law. The third supposition yet remains to be mentioned. When a minister is confident of the existence of the prerogative, and that the necessity for exercising it has arrived, there can be no occasion that the immediate representative of the executive should advertise for a parliamentary discussion. Let him use the instrument in the manner in which it was left by the constitution to be used. The opposition for the time being have it always in their power (and may be usually trusted for the inclination, as in the late Dutch embargo) to press the question to issue, and obtain the opinion of parliament upon both the point of right and the point of policy. For, on state-questions of this description, the members of a government are as answerable to the community which they serve, for mistakes in policy, as for mistakes in right. The distinctions were only of use before the House of Commons ventured upon the general superintendence which it exerts at present. Blackstone observes, that "the king, in the exertion of lawful prerogative, is and ought to be absolute," subject to the responsibility of ministers. Yet, from the nature of the case, as it is now understood, the king cannot be more or less absolute, nor his ministers more or less responsible, within than without these bounds. An unlawful prerogative may be assumed, a lawful one may be abused. As long as the constitution lasts, the king is in both cases alike personally secure. The unconstitutional adviser is in both cases equally answerable upon impeachment, and to the same degree. The decision against general warrants, when the official practice of three quarters of a century was at last brought into a court of justice, exemplifies the jealousy of the law in its own defence. The truth is, that the most satisfactory account of the mysterious maxim, that the king can do no wrong, since for every act done by him there must be responsibility somewhere, is an innovation which even the Revolution itself did not immediately introduce. The earliest strong assertion of it which Mr Hallam has perceived, is in a speech by the Duke of Argyll in the year 1739. Public opinion must have stopped short indeed, when a Whig, like Burnet, thought ministers were liable for advice given at the council, but not for the resolutions taken there; that is, they were to be liable for their own words, but not for the act, which might be the act of the sovereign himself. Whilst this distinction remained in force, it was possible that the whole question in these cases might turn on the limits of prerogative, and on the fact, whether the necessity of coming to parliament for fresh power could be evaded. This distinction, or something not distinguishable from it, was the shield behind which, strange as it now appears, both Whig and

Tory ministers, Somers as well as Harley, alike retreated, since the Revolution.

Prerogative, as above treated of, regards solely the remnant of those powers and privileges which had been vested in the crown from time immemorial by the common law. What is left is a small portion of a heterogeneous sovereignty, which had been originally wrested from a weak community by mere force, or which pertains to principles and circumstances long since decayed. From a sort of obscure traditional feeling, the word prerogative is more associated in men's minds with the personal will and pleasure of the sovereign, than with his political and strictly legal duties. The thing itself has, however, gradually fallen into the general mass of executive authority. Considered in this point of view, great additions have in later times been made to it. These additions consist of powers derived directly from parliament, and transferred to the supreme magistrate on the simple supposition that they are necessary for the public welfare. The preliminary question, Are they indeed necessary? occurs still more naturally on a demand that new powers should be granted, than on the suggestion that ancient powers might properly be retained. It is only when that point has been made out, that a prudent legislature will enter on the consideration of the precautions by which their abuse may be prevented, whilst their efficiency is maintained. To mention only one or two examples: The patronage of office has its risks in a free government. Yet it must be remembered that Polybius saw, in the influence which the contracts and public works gave to the Roman senate, the necessary link by which its connection with the Roman people was held together. At all events, the disadvantages of the actual extent of ministerial patronage belongs to the greatness of the British empire, and to the nature of its colonial possessions. The most rigid economy can alone reduce it within certain limits. An enormous national debt must still leave the public burdened with the additional evil of a proportionately enormous fiscal law; more equal in its assessment than, but perhaps almost as harassing as, the ruder aids and incidents of feudal jurisprudence. It is made both more costly and more pernicious, from the childish weakness of insisting that the bitter pill, if it must be taken, shall be concealed under the form of indirect taxation. The difference in the powers, as given by the common law and by the riot act, to public officers over unlawful assemblies, is scarcely so great as to be considered a dangerous augmentation to the force of any government. At the same time, whatever it may be, the same authority, or something very like it, may have become necessary for the preservation of the peace, when a vast manufacturing population is collected together on one spot; liable to be thrown out of employment at every moment by the oscillations of trade; accessible, besides, and accustomed almost daily to the most inflammatory appeals. This is the case also with regard to the extension of a regular police, and to the employment of the military in subordination to a civil magistrate. The change, however, which would most surprise Whitelocke and the patriotic parliamentmen who argued the militia question under Charles I., would be the mutiny act and the army list of the present day. They would think that the king might well consent to the concession of coming to parliament for its sanction, as his portion of the compromise. The balance of power in Europe was the only cause at first assigned in justification of a standing army; and it is still the burden of the mutiny act preamble. Our immense provincial dependencies have also to answer for it in part. However, another and a domestic necessity must have been silently making prodigious way, when so cautious a statesman as the late Lord Liverpool defended in parliament the numerical increase of the army, not by a reference to the state of Europe or the colonies, but by a comparison between the amount of the population now and in former times. It would be impossible to govern with so slight a pressure as society is at present used to, without a strong executive. It is fortunate, therefore, that, from the systematic regularity which prosperous civilization has favoured, the actual powers of the executive government have become more consolidated, and their operation more uniform. The effect of the whole is, that in Mr Hallam's opinion at the time of writing his invaluable work on the constitutional history of England, the English executive, "though shorn of its lustre, has not lost so much of its real efficacy, by the consequences of the Revolution, as is often supposed; at least, that with a regular army to put down insurrection, and an influence sufficient to obtain fresh statutes of restriction, if such should ever be deemed necessary, it is not exposed, in the ordinary course of affairs, to any serious hazard."

On the supposition that this opinion was correct at the recent period when it was delivered, experience alone can determine how far the supposed influence alluded to in it has been affected by the subsequent change in the constituency of the House of Commons. The supposed euthanasia of the English constitution, namely, the establishment of that simple monarchy which Hume and other writers have predicted as its natural fate, has been thrown back to an indefinite distance by parliamentary reform. If any thing like the same good sense and good fortune which have hitherto prevailed in the history of the people and their government shall be continued, there seems little reason why they should be thought to be hurried, by a measure of that principle and extent, within the perils of the opposite extreme.

Neither the principle nor mechanism of the reform bill has so changed the nature of the account. The difference of opinion entertained by different persons on a general comparison of the forces at work in the English constitution, seems of itself positive proof that the variance, whether before or since, has been only in the inclination, but that the constitution is on its balance still. At the same time it must be admitted, that the interest which was strong enough to carry the reform bill, is tolerably secure. It is not difficult to prognosticate what would have been the issue of open resistance to the new political adjustment which has been settled upon its terms. It was impossible, also, from the causes which urged it forward, that the adjustment could have been much longer peaceably delayed. The impoverishment of the crown by the alienation of the royal demesnes; its abandonment of claims and maxims become odious or ridiculous; its political incapacity to act on the House of Commons by the disfranchisement of old or by the creation of new boroughs; the scandal of private nominations, the still greater scandal of corrupt corporators and bribed freemen; the doors of parliament thrown open to the people through the publication of the debates by means of a daily, almost an hourly press; the increase of dissenters, displacing the monopoly of the clergy; a liberty, nay license, of discussion, popularising crude analogies to a new and kindred democracy in the United States, and reaching over every question and up to every individual in the land; public opinion circulating from one end of the kingdom to the other, and brought concentrated with electrical rapidity at any moment to any point; the rights of conscience, of free opinion, and of political equality, so proudly recognised that they overcame at last even all the recollections arrayed against the Roman Catholic persecution of Protestant reformers; the universal responsibility of ministers for every act of government now as universally acknowledged; the rise of immense towns, swarming with active artisans easily excited and easily combining; the constant accumulation of numbers, competence, and intelligence in the great and powerful body of the middling classes; the disappearance of the last relics of feudal castes and prejudices; the swamping of the ancient historical nobility by a modern aristocracy of wealth, favouritism, and corruption; the final breaking up even of the court and country party, whilst in their stead had risen up and found themselves face to face, those two parties which must always exist in open commonwealths—on one hand, the honest and also the servile partisans of power—on the other, the seditious and also the constitutional friends of the people;—these are but a part of the alterations which had changed not only the face but the core of England. A new soil, so to speak, had been turned up. A revolution in society had outstripped the Revolution of 1688. The rights of Englishmen, as Blackstone calls them (but what are in truth the rights of man, wherever man is civilized enough to understand and to preserve them) had grown into fuller consistency and bulk. The national system, now in its manhood, made, as it were, more blood, and required that the arteries should be enlarged which were to carry it to the heart.

A political student, after looking at the points to which all governments should strive, at the imaginary commonwealths of theory, and at the degree of approximation which, from amongst their thousand experiments, mankind appears to have ever realized, may think that there is good reason to be content both with the end and with the means which the English constitution recognises and secures. He will perceive that English liberty was long heavily mortgaged, but that the mortgage was never foreclosed. Its standard-bearers were sometimes down, but the pennon itself was always flying. Nations who regard England as a model, whether to be copied or to be surpassed, should remember that no nation can hope to buy a suitable constitution ready made. The end ought to be one all the world over, namely, the happiness of the people. But the condition of the people may be so different, as necessarily to demand the greatest difference in the means. The quantities with which moral and political problems have to deal, so far from being fixed, are in constant fluctuation; and the truths which they have to establish can never be tried by taking extreme cases. An assimilation and correspondence between that which acts and that which is acted upon, are conditions grounded on the nature of the human mind. In no case is strict attention to them more indispensable than in the relation between a people and its institutions. The best security for this is gradual adaptation. The Americans take English experience and English character into new circumstances, with the woods to back them. They may ride with a looser rein, and may try bolder tricks in legislation, than, in an old, densely-peopled, and overwrought community, any person, at least any reasonable person, acquainted with human nature and the difficulties of the case, could venture to recommend. They will not undervalue the necessity of such compromises with the nature of things and of events; since, in truth, no country ever made a greater sacrifice to the predominance of circumstances over principles than America has made, and is still making, over half her empire, in the most fatal of all exceptions. It is a worse one than the barbarism of the barbarous age of Magna Charta; an exception limited not even by the test of freedom, but that of the colour of the skin. It may be doubted whether the English experiment would not have failed, as the same experiment failed elsewhere, if its authors had rushed in the first instance to the point where their posterity at present stand. Light things may hurry forward, but the elephant must make sure of every step he takes.

A free government must be complicated in its parts. The checks introduced by circumstances, habits, and opinions, and which have been subjected to gradual amendments, remain a hundred times more effectual than any mere appeal to reason, which is all indeed that a totally new system has to make. The latter, however theoretically superior, must trust to its argumentative merits for its hold on the minds and affections of mankind. Montaigne expresses great contempt for long philosophical discussions concerning the comparative advantages of different forms of government. When he refers not only in opinion, but in reality, to usage as the sole criterion in every case, he is guilty of a gross exaggeration. This however ought not to prevent due respect being paid to the truth on which the very exaggeration is grounded. The whole history of England is the narrative of a long preparatory schooling to fit its people for their actual institutions. Institutions certainly are faulty which cannot stand the more summary test of Pope, when he disposes of these questions by a single line, "whate'er is best administered is best." For this in sensible prose must be understood to mean that the government is best which contains the best provisions for securing a good administration of all public affairs which depend on the relation of the governors and the governed. This security, it will appear by the description which has been given, it is the great object of the English constitution to establish by the proper formation and distribution of the legislative, judicial, and executive power.

II.—LAWS.

The civil law approached to the character of a universal language. The breaking it into fragments on the fall of the Roman empire, and the substitution in its stead of the coarse and mixed materials of the barbarian and feudal codes, had the effect of the confusion of tongues. Each code was nothing more than a partial dialect. Whilst the rest of Europe fell back more or less under the legal dominion of its ancient master, England alone stood out. It was impossible, however, that it could altogether resist an influence so universal; and it is probable that a greater impression was incidentally received than contemporaries were aware of, or than antiquarians have since been at the trouble to retrace. Mr Hallam observes that a good work, pointing out the extent to which the Roman law affected Bracton and his successors, is a desideratum in our legal literature. Nobody has yet felt a sufficient interest in, or been sufficiently conversant with, both systems to supply it. The distance to which England was thrown from the common orbit of classical jurisprudence, appears to have been even something more than the difference which separated the northern and southern divisions of France, where the one was subject to a customary, and the other to the Roman law.

English civilians and foreign scholars always treated the vernacular common law with the greatest possible contempt. John of Salisbury, in the reign of Henry II. calls it *aucupatio verborum*. Whitgift derides the learning which is learning nowhere but in England. Erasmus must have seen it to great advantage in the person of Sir Thomas More; nevertheless he mentions its professors in terms scarcely more respectful than the scurrilities of the college-play of Ignoramus, got up in its ridicule for the entertainment of James I. Evelyn is content so that he escaped from it with no harder word than "that impolished study." The provocation given by Law-Latin and

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Law-French has since been got rid of; that of tenures and their commentators still remains. Any insular jurisprudence, growing up during the middle ages, must have certainly suffered in its philosophy and its symmetry by excluding the written wisdom of the Pandects. By way of compensation, it is suggested that the alienation was of great advantage to English freedom. Whatever was gained in this direction is probably to be attributed more to the class to which the professors of the two systems respectively belonged, than to the supposed exemption of black-letter precedents from the arbitrary spirit of the imperial constitutions. The Inns of Court were long the principal seminaries in which the gentry of England completed their education; whilst, in the universities, the foundations for the study of civil law rivalled those for the study of divinity. The civilians and canonists, cousins-german by descent, thus became twin-brothers in feeling. In fact, civilians were formerly almost always churchmen. The difference of pedigree between them and the common lawyers was visible down to the time of Laud. The civil law, in any comprehensive sense of it, may be said to be extinct in England. To the degree, however, in which it exists, the English constitution is likely to find as warm supporters at present in Doctors Commons as in Westminster Hall.

The first point, on inquiring into the laws of a country, is to ascertain where the power of making them is lodged. It is very desirable that, as far as possible, the power should rest exclusively with the distinct and supreme authority of a recognised legislature. In this manner, laws adequately and publicly discussed will receive perhaps as general and as efficient a promulgation as the subject admits of. Certainly no better security can be devised against the possibility of constructive and *ex post facto* liabilities, than the practice of open debates, and the rule that legislative measures shall be strictly prospective. The connection between legislation and legislature is the doctrine of the English law. It can nowhere be expressed more strongly. But the history of what is called the common law shows the difficulty of acting upon it throughout. Popular customs will have already taken root before a steady government is formed, or, at least, before it is so far universally established, as to take under its cognizance the whole field of legislation. With regard, therefore, to this class of self-sown customs, the best thing probably that the legislature can do, when it becomes adult, is to acquiesce in them. Certain divisions of the law, and those not the least intricate and important, will from time to time be elaborately commented upon in text-books. Particular rules will also be adopted by the profession; and these soon become the grounds on which properties and expectations rest. For instance, "the practice of conveyancers" easily goes the length of making by necessity the law in that department. Much more is this the case with the opinions and the practice of the regular tribunals. For this purpose it is by no means necessary that the statute-book should contain an intimation corresponding to the threat of the *Code Napoleon*. "Le juge qui refusera de juger sous prétexte du silence, de l'obscurité, ou de l'insuffisance de la loi, pourra être poursuivi comme coupable de déni de justice." Direct legislation must be infinitely more active, and must complete its work in a far more workmanlike way, than the parliaments of the Plantagenets, and even than the parliaments of to-day, not to leave vast chasms for judicial construction to fill up. The English law at different periods has been indebted to all these collateral sources in different degrees for accessions to its wealth. Nobody can now determine how far Alfred and our other supposed lawgivers collected or composed the documents transmitted in their names. It is not the less unreasonable to assume on that account, with Chief-Justice Wilmot and others, that the "common law is nothing else but statutes worn out by time." Madox has observed that the laws of the Anglo-Saxon kings are as different from the writings of Glanville as the laws of two different nations. Some of the points are brought out in contrast in the second volume of Mr Hallam's *Middle Ages*, p. 466. Yet, if we are driven to any particular date for the origin of the present common law, it must be a moment not much anterior to the age of Glanville. He wrote as early as the year 1180; and the laws called by the name of Henry I., which are in their spirit thoroughly Anglo-Saxon, must, by their mention of Gratian's decree, be as late as the very end of the reign of Stephen. Mr Hallam makes a very judicious suggestion. He supposes that these laws, like the water ordeal for the common people, contain the ancient usages of inferior jurisdictions, whilst the treatise of Glanville, he conjectures, comprehends only the rules of the Norman lawyers, by which, through the influence of the circuits, and by other means, the former were gradually superseded. The unwritten usages were become completely fixed by the time of Bracton's compilation, towards the end of the reign of Henry III. There are no grounds whatever for conjecturing that these fluctuations were preceded or ratified by any direct legislative notice.

At a later period, namely, in the year 1322, it was explicitly enacted that all matters to be established for the estate and welfare of the realm should be treated in parliament. After so solemn and public a declaration, it might much more plausibly have been supposed that every subsequent alteration, whether in the civil or in the criminal law, would be accompanied by a parliamentary sanction in evidence of its title. What a change, however, took place both in one and the other; yet no "statutes worn out by time" can here be pretended. It is indeed remarkable that the statutory changes long bear but a small proportion to those which were obtained from other quarters. Although usage after this period can have crept in only now and then imperceptibly, undoubtedly the sages of the law kept insinuating their opinions, even extrajudicially, from time to time into the system. But by far the greater part of the innovations, real and apparent, were derived through the means of judicial decisions preserved in reported cases, and argued out by help of what has been quaintly called the "logical deduceableness" of the principles of the common law. The grounds of every judgment were set out on the record till the reign of Edward III.; afterwards they were taken down by certain grave and sad men in the year-books; and latterly, they have been left to reporters of a less accredited description. These precedents constitute an immense repertory of case law. If regard is paid to the smallness of the basis compared with the vastness of the superstructure, the ordinary course will appear to have been the synthetical formation of general rules out of the application and extension of individual instances. The portion, however, is far from being inconsiderable, in which the judicial classification of particular facts has proceeded according to the *allegata et probata*, under certain established principles. Looking at the history of the science, Burke was justified in saying, in the report of the committee upon the impeachment of Warren Hastings, that "to give judgment privately, is to put an end to reports; to put an end to reports, is to put an end to the law of England." Reports of the leading cases are especially valuable where society and the law are in a state of transition. Without them, the law in such periods soon becomes what Lord Bacon says the law of his time would have become without the reports of Lord Coke, a ship without ballast. The whole equitable law of the court of chancery, now tied up as strictly as the common law itself, has been spun, with but very slight exceptions, out of maxims of conscience and limits upon discretion, laid down judicially at as late a day as that of Lord Nottingham and the Restoration. That part of the English system where at present the lucubrations of twenty years are more wanted than in any other, was still in its infancy little more than a hundred years ago. Sir Mathew Hale said, in 1672, "a little law, a good tongue, and a good memory, would fit a man for the chancery." Evelyn, noticing the death of Chief-Justice Treby, in the year 1700, adds, "The chancery requires so little skill in deep law learning, if the practiser can talk eloquently in that court, that probably few care to study the law to any purpose." Lord Nottingham could not have desired a successor more admirably qualified than Lord Eldon, to remove from his court the last traces of this reproach. His ingenuity and erudition, however, only added still further to "the mass of learning which no industry can acquire, nor any intellect digest." Vesey junior, and his voluminous successors, have accelerated the predicted "crisis of a necessary Reformation, when our laws, like those of Rome, must be cast into the crucible. It would be a disgrace to the nineteenth century, if England could not find her Tribonian." (Hallam.) Mr Bentham admits that this legislative crisis will find, in the store-books of our reports, materials of a higher and more authentic character than were ever in the possession of any other country. Although the amendments of the law in the last session of parliament were more extensive than those of any single reign since Edward I., they nevertheless do not affect to have been of a nature to ascertain the existence or non-existence of a present Tribonian amongst our reformers. The extent of the alterations which have been begun or are anticipated, may be understood by the complaint of a member of the profession, who has particular means of information. "I regret to find (says Mr Chitty, in his *Concise View*, 1834) that *students*, whether for the bar, or as special pleaders, or as attornies, have of late nearly suspended all study, upon the supposition that, whilst innovations in the law are so frequent, it would be useless one day to learn what must perhaps the next day be forgotten or effaced."

A wise legislature will establish municipal rights in all cases, when by so doing it increases the sum of human happiness. These rights must be derived from the several sources of human pleasure. They therefore necessarily regard property, person, station, character, or opinions. Rights are public or private. Out of the first arise questions between the governors and the governed; to the second belong the disputes of individuals. The classification of these two descriptions of rights, and the specification of the circumstances which are the occasions upon which they vest, constitute the constitutional and the civil code. But rights are delusive unless protected by adequate guarantees. It is the first object of the remedial law, therefore, to define the circumstances which amount to a legal violation of whatever rights the substantive law has conferred. If the injury is considered to affect the public, its recurrence is sought to be prevented by subjecting the wrong-doer to the penalties of the criminal code provided on behalf of society at large. If the injury is of a private nature, the party injured is entitled to recover damages in the civil court for his own personal satisfaction. The mode by which the appropriate legal remedies for an alleged injury are ascertained, is called the trial. Since every case may involve disputed points of law and fact, it is requisite to make complete arrangements for deciding both. The efficiency of a trial will depend upon the constitution of the several courts, and the rules for regulating their proceedings. The first part of this problem concerns the number and locality of the tribunals, the principle upon which each of them shall be formed (as whether of a single judge or more, and with or without a jury), and lastly, the scale of appellate jurisdictions. The chief considerations relating to the proceedings concern the rules of pleading and of evidence, or the method by which a party is required first to make his statement, and afterwards to prove it. When the trial has established the merits of the case, and fixed the nature of the remedy, nothing remains but that proper means should be provided for carrying the judgment of the court into effect. This can be only done by making the property, and, on just occasion, the person, of the defendant duly available to the requisition of the law.

1. *Constitutional Law.*—This has been treated of in the former section. The shape in which the Roman civil law has come down to us, as recast at Constantinople by the imperial jurists, contains not a syllable which can be referred to the supposed resemblance between the mixed forms of government of ancient Rome and modern England. Excepting a few slight privileges belonging to the peerage as members of a second legislative assembly, English equality recognises no distinction but that of aliens and natives. Our doctrine of the unalienability of birth-allegiance, and our restraints on naturalization, are pushed to an illiberal extreme. But it is a great blessing to have escaped the useless and onerous diversity of castes by which Roman policy was embarrassed, and American freedom is disgraced. England is safe from the interminable questions of political rights and civil condition arising among the *ingenui, liberti, servi;* and under the discrepancies of the various kinds of citizenship and the *Jus Italicum* and *Jus Latinum.* Shades of colour have introduced the risk of even still more dangerous collisions into the United States.

2. *The Relations of Private Life.*—Under the English law these relations were for the most part either settled upon, or have been since gradually brought within, the true principle, namely, that of deriving from the connection the greatest advantage to both parties, which, on a comprehensive view of their interests, the particular relation seems qualified to produce. On legislating upon this subject, our law-makers have not overlooked the painful fact, that there is no occasion where it is more necessary to keep constantly present to the mind the line which separates morals from law. The poor-laws and the factory bill are doubtful exceptions, in which the feelings of society may be suspected of having got the better of its judgment. Otherwise, the law has generally forborne from becoming responsible for those private virtues which no law can possibly secure, and has shrunk from an interference far too powerful not to tend to defeat the end it is desirous of accomplishing. In the service of adults, the contract between master and servant is the only criterion both of their claims and of their liabilities. The maxim that slaves cannot breathe the air of England, has at length comprehended our distant colonies within its blessing. The extension of a haughty local privilege into a national truth is the proudest triumph of the humanity and justice of modern times. The relation of parent and child is placed upon proper grounds. Parental authority is reasonably limited to the degree of power necessary for the adequate performance of the duties which every parent is understood to undertake. The most faulty part of the legal distinction between legitimate and illegitimate children is not in the degree by which the parental obligation towards them is distinguished. The feelings of society must first alter, and the policy of our rules, and the most effectual method of attaining our object, must be carefully reviewed, or very

little practical benefit will follow from a nominal amendment of the letter of the law.

The difference by nature and education between the sexes placed the female sex in the East, in Greece, and in Rome, in a permanent tutelary condition. Their disabilities were doubtless represented, as in the case of minors amongst ourselves, to be in reality privileges of protection. Modern civilization has transferred this state of imbecility from women generally, to women who consent to assume the character and *status* of wives. The marriage contract cannot be regarded as an ordinary partnership. Women are certainly the half of the species much the most interested in the rule, that a contract, more or less resembling the marriage contract as it is actually established, should subsist. The only question which their advocates can raise must be upon its terms. It is admitted that the terms are partial. The question still remains, Can they be improved? Nothing is more imprudent than to volunteer speculative changes in an engagement of this domestic nature, without infinite caution in examining into the capabilities of the case. It is impossible to equalize its effects and condition to the two parties. There is an extreme risk of injuring the female by the very precautions and facilities which it has been proposed to interpose in her favour. The interest which other parties (the children and society) have to keep families together, the first of those concentric circles by which a well-ordered community is formed, introduces a new and paramount consideration. The more the subject is reflected upon, the more will it appear that the English law of husband and wife requires only very incidental modifications. By the late amended marriage act (3 George IV.), the reluctant successors of Lord Hardwicke were compelled to retrace his steps, and to submit, on the marriage of minors, to the compromise of *factum valet, quod fieri non debet.* The debates on that occasion affirmed in the most striking manner the necessity of recognising the least of two evils in this delicate chapter of jurisprudence. No necessity, however, exists at all for making parliament the sole tribunal where a marriage can be dissolved. It is a singular anomaly, that this particular contract should become the subject of individual and *ex post facto* legislation in every case where parliamentary divorces for adultery are allowed to break in upon the ordinary law. Our practice does not leave a doubt that the contract should be legally voidable for adultery. But it is very questionable whether, on transferring this jurisdiction to courts of justice, the interests of society in general, and of females in particular, would be promoted by the admission of any other grounds of divorce whatsoever. Nevertheless Cranmer, in the proposed reformation of the ecclesiastical law at the Reformation, was prepared to give to many of the causes on which a separation takes place at present, the effect of a complete dissolution of the marriage. The rule which, subject to a few exceptions, prevents a husband and wife from giving evidence either for or against each other, seems very unreasonable. The legal consequences of marriage do not depend, as Blackstone states, upon any canonical union of persons, which can be supposed to suspend or merge, during coverture, the legal existence of the wife. These consequences are much better accounted for by the rustic simplicity of ancient times, which regarded the wife as only a servant of a better fashion. It is evident that a family partnership, which, when it has once been formed, can be determined only by death or by criminal conduct of a serious nature, requires a conjugal superiority on one side or the other. In this view the law is censurable rather from the discourtesy of the occasional language of some of its authors, than the substance of its provisions. The superiority is certainly evident enough. There is the spiritual promise at the altar to obey, and the legal solemnity which makes it petty treason to kill her lord and husband. Marital restraint and correction carry the power of domestic discipline, in the case of a wife, a greater length than in that of any other servant, except an apprentice. The principle of considering the wife incapable of committing certain crimes in the presence of her husband, owing to her supposed submission to his orders, is made additionally absurd by the inconsistency with which the supposition is applied. It is time that on one or two of these points the law should be put into harmony with the fact. There might also be a wholesome relaxation of the rule by which a married woman is prevented, under all circumstances except the civil death of her husband, from being sued as a single woman. The landed property of a wife could formerly be alienated only by a fine. It was imperfectly protected against the exercise of undue influence, on the part of a grasping husband, by her separate examination. Her real and also personal estate may be made safe enough at present. As far as property is concerned, the devices of a marriage settlement, and the interposition of trustees, seem to accomplish every thing which can possibly be accomplished by law.

3. *Real Property.*—The lawyers of Greece and Rome had no idea of the necessity of two systems; one for land, and the other for goods. In England the systems are entirely distinct. The civil law of England during a very considerable period seems to have had little else but land to treat of. It characterized land by the expressive denomination of realty; and distinguished it still further by establishing its legal title and qualities on exclusively feudal principles. Hypothesis and research will be equally at a loss to make out any analogy between the Roman Institutes and Littleton's Tenures. The language of Craig would have been unintelligible to Papinian. Where the same word happens to be used, it only deepens the contradiction by the difference in its meaning. Dower, for example, by which the Romans described the property which a woman brought with her on her marriage, signifies, in our modern application of it, the life-interest which, on the death of her husband, the widow acquires to a third of his land. The changes in society gradually made it impossible to retain the strictness and also the peculiarities of feudal learning. The "old books" were already antiquated, and several of their cases seldom came into practice in the time of Sir Mathew Hale. The new reports, such as those of Coke, Plowden, and Dyer, the exact perusal of which he pressed upon his student, are now become "old books" themselves, and are approaching towards a similar fate, partly by statutory repeals, partly from desuetude or ignorance, under a still greater revolution in the law. The wave from the commonwealth which, during the reign of Charles the Second, carried off part of the rubbish of former times, did little in comparison with what has been done in the first session of a reformed parliament. The abolition of fines and recoveries; the amendments in the law of inheritance and dower; the limitation of actions, by which writs and formulas of complicated absurdity, hazard, and expense, are gone for ever; hold out substantial encouragement to expect that the labours of the different law-commissions will in course of time be brought to a satisfactory legislative conclusion. In a practical point of view, the registry bill is by far the most important of their present recommendations. An undertaking of much greater difficulty, but fortunately much less urgent, remains behind. The principles, the reasonings, and the language of the law of real property, will not bear an enlightened examination at the present day. Nothing indeed can be more indefensible in the

nineteenth century than a legal system, of which such a book as Coke upon Littleton is the classic. It is a very imperfect answer to say that the opinion which Lord Mansfield once gave to a West India governor upon the law generally, applies especially to this part of it: "Decide according to your judgment, but give no reasons. Your decision generally will be right: your reasons always will be wrong." A code itself would be only a partial remedy, unless it superseded the necessity of looking back into the volumes which preceded it. Feudal doctrines are too completely woven into them ever to be worked out of their text. During centuries when the legislature either could not or would not act, judge-made law was by far the least of the two evils to which the country was reduced. The judges certainly did their best towards accommodating the law to the altered condition of society, by means of the only instrument in their power. But the course taken led naturally into a labyrinth of fictions and refinements, which it will now require pretty much the same astuteness to unmake, as was originally employed in the making of them. The complaint is not that the law is difficult to be understood. That might be expected. What shocks a reasonable person at the present day, is the finding that so many of its rules, when they come to be understood, are irreconcilable with either common sense or with the usages of the community which they govern.

Thus, in descent, instead of regarding the just expectations of near relations, the law is occupied in tracing the blood of the first purchaser. In forfeiture, instead of balancing the claims of the family on one side, and the claims of injured society on the other, the law can see nobody but the original feudal donor. In questions of the lawfulness of a distress, the difficulties do not turn on the point, whether the goods which have been seized represent under the circumstances the fair and natural security for the benefit which the owner of the goods has derived from the premises where they were found, but whether the landlord, on putting an occupier in possession of the premises, had taken care that the terms of the occupation were so expressed as to be sufficient technically to raise a tenure. Independently of judicial construction, successive innovations have materially broken in upon the feudalism of the common law. This is the case, particularly in the restraints imposed upon entails and remainders, in the free exercise of the testamentary power, and in the frequency of terms of years which are regarded by the lawyers as personalty. The most important of all innovations is, however, the extent to which the doctrine of trusts and uses has brought the principal questions concerning land into a court, where forms and principles in many respects essentially differing from those of the old common law prevail. The intermediate legislation respecting uses, from 50 Edward III. c. 6, to 27 Henry VIII. c. 10, is a characteristic specimen of the English method of creeping on step by step, after the mischief has run, like the dry rot, into the frame of society, instead of taking a comprehensive view of the necessary consequences of the new system, and anticipating the confusion by such a conclusive statute as, after all its previous minute enactments, it was ultimately obliged to pass. It answers in civil to the cautious manner with which in criminal jurisprudence the law of *mayhem* advanced, taking successively the different parts of the human body under its protection, one after another, until at last came a general measure known by the name of Lord Ellenborough's act. Blackstone, writing in 1765, observes that the Chancellors, "by a long series of uniform determinations *for now near a century past, with some assistance from the legislature, have raised a new system of rational jurisprudence*, by which trusts are made to answer all the beneficial ends of uses, without their inconveniences or frauds." Considering the strictness of the doctrinal division between legislative and judicial authority, and the traditional attachment to juries, the national submission to this legal revolution, consummated by the great seal, is a remarkable proof of the impossibility of working the system of the common law in the present state of society. It may be questioned whether any country ever adopted, at so comparatively an advanced stage of civilization, so complete a change; with little notice beyond an occasional murmur in some quarters at what was going forward, and that general ratification on the part of the public in the consent that comes from silence. The nature of a jurisdiction like that of Chancery, must be to enlarge, and not contract, its circle. It is now some time since Mr Butler was of opinion that half the estates in the kingdom were held in trust. But there are further changes than those of form. The very substance of certain titles which make a great figure in the law-books is wearing out. Two species of incorporeal hereditaments, common and tithe, to which an extravagant and superstitious importance was formerly attached, seem shortly destined to disappear; and they will carry with them into oblivion a mass of favoured learning. Common of pasture and of estovers was supposed to be so necessary to the advancement of agriculture, and to the maintenance of tenantry and yeomen, that a case connected with it drew forth from Lord Coke the passionate exclamation, "God forbid that the law should not be so, for otherwise many commons in England would be avoided and lost." Long after the Reformation, a still deeper horror continued to be expressed by Spelman and the clergy, at the sacrilegious spectacle of tithe in lay hands, or of land discharged from the payment of tithe. When the necessity of statutes of limitation has been recognised in all other cases, and when even the crown has submitted to be barred by prescriptions of a reasonable extent, the ecclesiastical rule which sent back the proof of a *modus* to a time beyond legal memory, was no less impolitic than absurd. The tithe owner has to contend at present against passion and prejudice, as well as against reason. A violent re-action has taken place. The discouragement to agricultural improvements, from a surrender of a fixed portion of the gross produce, is a ground of objection in which the public at large are interested. The result is, a demand for a general commutation of tithe, which cannot be much longer delayed.

4. *Personalty.*—It is agreed that Bracton borrowed the chief part of what he has said concerning personal property from the civilians. But the reader of the year-books finds himself at the reign of Henry VI. before goods and chattels have become of sufficient importance to make their way as the grounds of litigation into their records. The laws upon property of this description, and on personal contracts generally, are very much the same all the world over. This is probably to be accounted for, not by the supposition that similar laws must have had some common origin; but because these things are too perishable in their nature, and too much the subject of daily wants and traffic, to admit conveniently, under any circumstances, of any great deviation from a common line. The consequence is, that on this point, beyond some occasional quaint distinctions between what is realty and what is personalty, and a little absurdity concerning things which are merely the subject of base property and *nullius in bonis*, there is very little which can be noticed as peculiar in the English law. Where goods have been lost or stolen, the effect which, according to circumstances, prescription and sale ought to have in discussions between the original and the derivative owner, has been settled upon no discri-

minating principle. The rights belonging to an owner when he is out of possession have been slowly recognised in most countries. Blackstone hastily states, that unless a right of property were to be transferred by the sale even of stolen goods, in market overt, "all commerce between man and man must soon be at an end." He should have recollected that England offers the only exception in civilized Europe to the rule, "*nemo plus juris in alium transferre potest quam quod ipse habet.*" In the new questions which have arisen out of the extended intercourse and complicated interests of recent times, it is fortunate for the legal reputation of the country, that the demand for the development and application of the great principles of commercial and maritime law should have taken place at a time when Lord Mansfield and Lord Stowell presided in their respective courts.

5. *Private Wrongs.*—Every right must have its remedy, otherwise it is a right only in name. Verdicts with a farthing damages are sufficient evidence that the expressions *damnum absque injuriâ*, and *de minimis non curat lex*, are confined in practice within narrow bounds. The forms of actions are, in other words, a list of the cases which the law recognises as civil injuries, and which it accordingly promises to redress in that character. One of the great boasts of the English law is the means which it has taken to render illegal imprisonment almost impossible. This was at last obtained, but with infinite difficulty, under the final guarantee of the habeas corpus act. There is nothing otherwise remarkable in its estimate of the wrongs either to the persons or to the personal property of individuals, or in the general quality of the remedies provided by it. The injuries to real property, and the peculiar remedies applicable in the several cases, partake strongly, at least in shape and in language, of the characteristic subtlety and jargon in which the law of real property itself is framed. There are instances, however, with respect to personal property as well as real, where the strictness of the rules at common law had the effect of a denial of right, and drove the parties into a court which undertook to adjust the remedy to the wants and feelings of society. Chancery would never have obtained a tenth part of its present jurisdiction, but that the common-law judges contented themselves with damages, instead of insisting that a contract should be specifically performed and goods specifically restored; and unless they had obstinately refused, since the introduction of uses, to notice the existence of a trust. The bankrupt law has lately been put upon a footing which appears likely to give, in its text and its administration, as much satisfaction as can be imparted to so untoward a subject. Nor does it follow that tradesmen who complain of the million that is discharged by a penny in the pound, are entitled to lay the blame upon either the policy or the execution of insolvent acts. The only effectual protection, that of more cautious credit, is in their own hands. The Roman system placed the debtor at the mercy of the creditor. The American system, according to Chancellor Kent, throws the creditor at the feet of the debtor. The experience of all countries seems to show, that in legislating upon insolvency, it is impossible to reconcile the claims of humanity and of justice by the positive declarations of a universal rule.

6. *Criminal Law.*—Whenever the circumstances and motive under which a legal right is violated imply an injury to the public, it is reasonable that the remedy should cease to be solely of a private nature. The English law is defective in not endeavouring to combine reparation to the party directly injured, as a subordinate object. But it properly considers the mischief to the public, and the remedy for the public, as the paramount concern of criminal justice. The comparative alarm spread throughout society by different offences is the test of their several degrees of responsibility; nor is society entitled to take a criminal cognizance of them at all, save with the single aim of preventing their recurrence. The original point in this respect, from which the common law started, and the mode in which its circle widened, were too coarse and vague to admit of much discretion in the selection of the principle adopted, or of any very uniform correctness in its application. Civilization has tended gradually to exclude from the purview of human punishment the spiritual doctrine of expiation and the savage instinct of resentment. Proceedings *pro salute animæ* are left to the ecclesiastical courts; and the abolition, by 59 George III. c. 46, of appeals at the suit of the party in all offences, has removed from criminal proceedings the last symptom of private vengeance. Up to a very recent period felony was heaped upon felony as a matter of course, whenever a new or temporary provocation happened to arise. No wonder, where it was impossible that due attention could have been paid to the nature even of the specific evil and the proposed remedy, that the just proportion between the new offences and the great body of the criminal law should have also been neglected. In fact, they often seem to have taken their place by chance upon the penal scale. During the last few years the consolidation of great part of the criminal statute-law has been performed in a very workmanlike manner. The repeal of a multitude of obscure and almost conflicting enactments has been of great service to the public, and still more to practitioners. It has simplified the labours of future reformers. But a comprehensive view, a consistent direction, and a rational arrangement of the whole subject, is a task reserved for the commission now engaged upon it. The interests of society, as protected by the criminal law, are technically called the king's peace; and all offences against these interests are prosecuted in the king's name. But it is singular that, nevertheless, the burden and the management of criminal prosecutions, and, in popular language, the name even of prosecutor, should, contrary to the practice of many countries, be thrown upon the party injured. The principal legal consequence which has followed from taking the prosecution formally into the hands of the state is, that society obtains the evidence of the party injured, who would otherwise be excluded as being a party to the suit. The original object of using the king's name in this formal manner was probably to entitle the king, as a matter of course, to the penalties and compensations. A barbarous and fiscal rapacity was thus tempted to scatter wholesale forfeiture with indiscriminate profusion over the field of crime. The 25th Edward III., called the magna charta of treason, had no nobler origin than a contest between the king and the barons, which of the two should appropriate the confiscations upon conviction. They belonged to one or the other, according as the offence was treason or ordinary felony. It may easily be understood, therefore, what little principle exists in the rude classification of offences into felonies and misdemeanors, distinguished only by the nature of the punishment; the one being subjected to general forfeiture, and the other to special fine. Under these circumstances, a strict revision of the entire department of the criminal law, keeping steadily in view the one principle of the good of society, must bring to light anomalies and divergencies which it will be no less desirable than practicable to remove. This is likely to be the case much more in some questions than in others. For instance, the purely religious sentiment was formerly mixed up with the only consideration which can justify human laws in inquiring into offences against God; and it still partially remains so. Judicial perjury is punishable simply

under the general description of being the violation of an oath. If the religious obligation is alone regarded, it may be contended with some plausibility that the breach and the offence must in all cases be the same. But if the danger to society be the point in question, it is clear that the danger must be materially affected by the nature of the case in which the perjury takes place. In some instances zeal without knowledge has been induced to pass the line by which morals ought to be always kept separate from law. The political economy of modern days has overturned many of the most sacred rules of policy and trade invented by the common-law wisdom of our ancestors. It is in vain that the corresponding statutes have been repealed, whilst narrow-minded judges feel a pride in proclaiming that unitarianism, forestalling, and engrossing, are still indictable misdemeanors. The same reasoning which annulled the statutory policy of the intermediate generations, ought to avail for abrogating equivalent absurdities, supposed to have been embodied at an earlier period in the original structure of the common law. In many cases legal definitions, as formerly in larceny, or the specific enumerations contained in an act of parliament, or the purview of a preamble, or the recognised jurisdiction of our actual courts, may be found to fall short of their proper object. It is plain to the understanding of the present day, that the terms of the statutes of treason, which left even Strafford's case to forced constructions, were too monarchical. The decay of the ecclesiastical courts, of the court of honour, and the abolition of the star-chamber, threw loose many offences which have never been examined and arranged on system. It may be doubtful whether seduction and adultery are properly left to a civil remedy only. A doubt however can scarcely be entertained but that the indictable character of words spoken, as distinguished from words written, ought not to be derived solely from their containing a consequent breach of the peace in their tendency to lead to a challenge. There is little foundation in reason for the general rule, which, in slander or libel, admits the truth to be pleaded as a justification always in an action, but never in a prosecution. A careful investigation of the true principles, which, in a compromise of difficulties, may be the best guides on many subjects, will lead to another very important consideration. A great deal of needless, and, what is worse, pernicious pains, appears to have been employed in turning into fixed rules of law what it would be much more satisfactory to the ends of justice to have left as questions of fact. This must happen in all subjects and occasions where the nature and tendency of the act depends on circumstances which it is almost impossible to define beforehand. Supposing, what we see no reason to suppose, that a common jury is incompetent to decide questions of fact of this description, it becomes the duty of society to create a competent tribunal. All offences of opinion are of this nature. But there are numerous others. Notwithstanding the complaint of Sir Thomas More against the judges of his day, that, in order to escape personal responsibility, they threw every thing on the jury, it is evident that, honestly and dishonestly, English judges have brought many points, as legal conclusions of the science, under their own judicial authority, which, as questions of fact, would have fallen, and much more properly belonged, to the province of a jury. National character is involved in the history of the public institutions and policy of a country. England, both at home and abroad, labours under the imputation that the letter, and even the execution, of its criminal law, are severe beyond the example of other states scarcely its equals in general civilization. The difference would appear by comparing a scale of offences and punishments under the English law with a similar table drawn up according to the progressive mitigations which have been attempted by America and France. It need not be feared but that the experience of opposite systems, and a patient discussion of the peculiarities of England, of the nature and circumstances of its population, the distribution of its wealth, and the free character of its legislation, are sufficient securities against vague and theoretical innovation. The result would ascertain what degree of success has attended the humane endeavours of the enlightened statesmen of other countries towards the amendment of their penal codes, and whether any just cause can be assigned why England may not safely venture upon imitating their example. The comparison of the nature of comparative anatomy between the laws of different nations may be very useful. In this instance it would be most satisfactory, were it to terminate, as some confidently insist, in proving that England has already redeemed its right to the distinction which it lost in and after the reign of Henry VII.—*Nulli gentium mitiores placuisse pœnas.* The executions during the reign of Henry VIII. are reckoned by Hollinshed to have averaged two thousand a year. Towards the close of the reign of Elizabeth they averaged annually about four hundred. Notwithstanding the vast increase of our population, and the supposed increase of crime, the criminal return for 1830 gives, on 12,805 convictions, the sentences to death 1397, and actual executions only forty-six. In France the criminal return for the same year (1830) gives, on 4130 convictions, the sentences to death ninety-two, and actual executions thirty-eight.

7. *Courts of Justice.*—The occasions are few and strictly limited, in which the English law allows the party injured, or his immediate relations, to right themselves. A third person cannot justify interfering on behalf of the private interest of even his dearest friend. It is only as a member of society that he can step forward on the public grounds of preserving the public peace. The great singularity of the chapter on preventive justice in the English system, is not, as Blackstone states, that there should be one at all, but that it is so short. There is nothing, however, which a stranger is not privileged in doing, in order to prevent the commission of a felony. In other respects, every one is understood to have transferred the redress of whatever wrongs he may sustain, as well of a private as of a public nature, to the collective justice of the community. Under these circumstances, it is the duty of the community to establish tribunals for a prompt, cheap, and efficient adjudication of the differences which must necessarily occur. The necessity of reconsidering the constitution and distribution of courts, both of original and of appellate jurisdiction, has been at last forced upon the English legislature. Original tribunals may be separated or combined upon four principles: *First*, by the nature of the causes, whether civil, criminal, or ecclesiastical: *Secondly*, By the importance of the proceedings; that is, according to the value of the matter in dispute, or according to the amount of punishment to be inflicted: *Thirdly*, By territorial extent: *Lastly*, By the number and description of the judges, and by the different forms in which justice may be administered in each. The English system admits all these principles.

The supreme courts are classed on the first principle. They were originally founded upon a positive metaphysical division, which went so far as to parcel out particular classes of civil causes to particular courts. Thus all controversies between subject and subject were to be taken into the Common Pleas; all civil questions which might affect the revenue were to be decided in the Exchequer; whilst the King's Bench had the proper cognizance of all trespasses which savoured of a criminal nature, in right of its transcendent authority for the correction of crimes and misdemeanors. By means of rival measures of ludicrous trickery, hardly worthy to be called astuteness, these courts gradually obtained in most civil actions a concurrent jurisdiction. But this jurisdiction unfortunately remained stationary while society advanced. In course of time Chancery took under its charge the vast civil interests with which the common law refused to interfere. Common lawyers were for a time indignant; but they seem, after the first unsuccessful struggle, to have shrunk from entering into competition with the political ascendency of the Chancellors. Consequently, the greater part of this equitable jurisdiction is what no fiction or rule of court has since been ingenious or venturesome enough to reach. Soon after the Norman conquest, it was the policy, perhaps, of the government, but still more of the church, to separate judicially the civil from the ecclesiastical authority. The King's Bench has revenged itself on Doctors' Commons for the encroachments of Chancery, and has always taken jealous care, by its prohibitions, to keep the ecclesiastical courts within their peculiar province. The province is still however considerably larger than present opinion would have made it; for it would be difficult to make out how matrimonial and testamentary questions are properly matters of spiritual concern. The suspicion entertained by Mr Bentham, that the metaphysical classification of courts must have been the result of a scramble between competitors, is not confirmed by our legal history. The scramble began with and brought about the consolidation. Nevertheless, although at first a deliberate arrangement, it seems to have been an injudicious one; and as such, it has been in a great degree abandoned. Every classification of the kind multiplies the chances of clashing jurisdictions. It creates also an additional risk of a failure of justice; since there is a chance the more of a formal error, by mistaking the appropriate tribunal. Each court, having less to do as the business is more minutely subdivided, can supply the judicial demands of a wider area. Thus is superinduced the further disadvantage of extreme centralization. Circuits by the supreme judges at stated periods only partially mitigate a portion of these evils. They have been in use for many ages, and have the very desirable effect of bringing the metropolitan courts nearer to the great majority of the suitors of the kingdom; but it is difficult beforehand to make the calculation of the probable business at the several places of a circuit, with so much accuracy as not to become the occasion of one or other of opposite inconveniences. Causes are often hurried through with indecent haste, or are got rid of by an almost compulsory arbitration; or great vexation and expense are incurred in waiting for a trial, which, after all, is obliged to be put off until the next assizes. The expense of our actual courts is a fatal objection to the exclusive authority which they practically at least enjoy. When it is at once universally admitted that it is cheaper to lose a debt of L.20, rather than to recover it by law, nothing further need be said. In the main examples under the English system for distinguishing courts, either according to the importance of the question, whether civil or criminal, or according to the extent of territory subject to their jurisdiction, both principles are generally combined. This is the case with the baronial, the hundred, and the county courts of the common law. The same combination was observed in the County Court for Middlesex, as settled by the 23d George II. c. 33. It applies also to the Courts of Requests or Conscience, and to the judicial authority given to corporations and to justices of the peace. The subjects which exceed the scale set to these limited jurisdictions, of course lose the benefit of being decided by a local court. By the supposition, a better court is understood to be provided elsewhere. The excluded cases are remitted to it, because either the difficulty of a cause, or the mischief of an erroneous judgment, rises with the amount of the property, and of the penalty which it involves. This is true to a certain degree, but to nothing like the degree necessary to warrant the universality of the rule; and least of all does it justify the distinction at the peremptory point where it is at present taken. Local courts of every description are now scattered up and down the country most irregularly. There are as many as sixty courts of conscience for the recovery of small debts, established among very unequal populations and at uncertain distances. They easily admit of being parcelled out on an improved system. On any reformation of them, the standard of value in civil questions ought to be materially raised. The judicial talent and legal knowledge of the profession, if properly selected, are fully capable of supplying the demand which the alteration would create. The necessity of local courts is a matter of contemporary fact and reason rather than of authority; but if great names are wanted, the plan drawn by Sir Mathew Hale is ample authority for the propositions of Lord Brougham. There can be no doubt but that the confidence of the public would soon be attracted to tribunals which, by their comparative accessibility, would reduce the delay, the vexation, and the expense, within very moderate compass. In this manner the most crying grievance might be removed, and the administration of justice universally facilitated, without giving to our permanent local courts an exclusive original jurisdiction of all cases whatsoever arising within their limit. The circuit system, though open to serious objections, might probably, in a balance of advantages and disadvantages, be the best practical compromise for the remaining difficulties. The periodical visits of the supreme judges, and the presence and example of the powerful metropolitan bar, have doubtless a very wholesome influence in the provinces. They constitute moveable local courts for the time being. In the great majority of cases, trials at bar must have been always out of the question; and much more so, while the metropolis was a place talked of rather than known in remote counties, than at present. From the earliest times, therefore, the courts at Westminster could not dispense with justices in eyre travelling to the spot. These deputations of the supreme judicial power are necessary consequences of the strict doctrine of venue, and of the most latitudinarian extension which has yet been given to the original necessity of summoning a jury from the scene of action. The size of France more naturally led to great provincial institutions, like the old French parliaments, or the actual *Cours Royales*, with their divers subordinate jurisdictions. The different courts existing in England for different purposes, vary considerably in the number of their judges, and in the forms by which justice is administered. Mr Bentham praises single-seated judicature. Aristotle, on the contrary, insists that one or more colleagues are wise precautions against the moral or intellectual obliquities of a single individual. The practice of England offers a choice of every kind. The varieties are varieties of accident apparently, not of principle. Courts of equity, and most of the courts which do not proceed according to the common law, have always afforded, and still afford, only a single judge. But the number in the supreme common-law courts fluctuated considerably in former times. That of the Common Pleas, for instance, has been nine, seven, six, four, and five; of which latter number the three principal courts of common law consist at present. On the circuit the number drops down to one, both in civil and criminal cases. The trial of a peer for

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felony takes place before the whole body of the nobility. The inferior courts vary equally. There are the manor and sheriff's court, with the crowd owing suit and service; the mayor and aldermen of corporations, assisted, or not, by their recorder; magistrates with summary jurisdiction, one or two in certain cases, up to the indefinite scramble of the bench at quarter-sessions. When members of a corporate body, and justices of the peace, render their judicial services gratuitously, the financial objection of a numerous judicature is removed. But it is only the financial objection; and a remuneration, more than adequate to the services performed, is likely to be often got in local influence, or some more objectionable shape. When the aggregate numbers stop short of letting in the passions which seize upon all large assemblies, even the majority may be yet likely enough to want the requisite character and knowledge. It is absolutely necessary to keep down this risk within certain limits. But the importance of interesting the higher and middling classes in the administration of justice may counterbalance in this instance, as in that of a jury, a small per-centage of errors.

If no very good cause can be assigned for the numerical varieties which appear upon the English bench on different occasions, it is perhaps still more difficult to give a rational account and justification of the distinctions by which the presence or absence of a jury is determined. The precise history of the institution, of its original object, and of the transitions through which it has passed to its present state, appears to be irrecoverably lost. But enough is left to show that it was a trial by neighbours, acting in the mixed capacity of witnesses, sometimes to facts, sometimes to character, as well as in that of judges ultimately determining the truth of the fact upon the result of the evidence. They were always the *patria*, but only in certain cases the *pares*, of the parties. As the law advanced to the dignity of a cultivated science, the line of demarcation between the facts which were to be proved, and the law which was to be applied to them, became strongly (occasionally too strongly) marked. If the temporary and casual inquest returned by the sheriff was recognised as the proper judicature for solving the question of fact, the permanent professional representative of the sovereign was alone competent to answer the question of law. The jury, growing up with, and itself a part of, the common law, was thus made the constant adjunct to its courts. It insured at all events publicity, without which every other excellence can give little security for real, and none for apparent, justice. Yet apparent justice is the source of the general confidence and satisfaction which forms one of the principal objects of government in all its branches. In their own limited departments, courts of equity, admiralty, and chivalry, arose under the civil law, and ecclesiastical courts under the canon law. Knowing nothing of a jury, they knew nothing of the above distinction; and the professional judge was of course entrusted with the decision both of fact and law. Cases in Chancery, where an issue is directed, are the mere exceptions of practice. There is nothing in the great majority of the questions which come before any of these courts, as compared with the civil questions which are tried at the assizes, to warrant a difference of this description. The interposition of a jury is matter of command in the one case, and of prohibition in the other; yet the rule rests only upon prescriptive usage, and not on reason. The legislature has often dispensed with juries, for obvious reasons. It is easy to understand how a jury is too popular an institution to be trusted with the administration of unpopular laws; such as laws enforcing rates, excise, and customs, must unfortunately always be. A more agreeable reason will justify the absence of a jury in some, but in some only, of the questions left to justices of the peace. Many causes are too free from difficulties, and at the same time too frequently recurring, to render it necessary or prudent to fill a jury box by means of a legal conscription on their account. Twelve citizens need not be summoned from the farm-yard or the counter to superintend the prosecution of all minor offences, and on every affair of correctional police. Whilst accidental circumstances have had the greatest share in establishing the distinctions by which in the higher courts juries are admitted or excluded, it would be as well to see in what cases some better criterion can be found. This would be wiser than the opposite courses which have been recommended by the extreme advocates of reform; an indiscriminate reception, or an almost indiscriminate refusal. A jury is an excellent tribunal for solving and appreciating ninety-nine out of one hundred of the combination of facts with which criminal justice has to deal. It is thoroughly qualified to determine all cases of intention, and assess almost all questions of uncertain damage, as in actions of libel and of trespass. Whatever abuses may stain certain periods of our history, the institution has well earned the traditional reverence with which it is regarded. It is entitled, on collateral accounts, to the respect of the lawyer and to the gratitude of the people. The distinction by which a question belonged to the judge or to the jury, according as it was a question of law or of fact, impressed a peculiar character upon our legal proceedings. It was the occasion of the remarkable simplicity and precision with which these separate questions were early discriminated in the English law. The national character of Englishmen has become remarkable for its almost judicial sobriety, and for the degree in which a deep sense of justice and an invincible respect for property are singularly combined with popular public spirit. How much of these, one or all, may be owing to the immemorial co-operation of the people in the administration of the law, is more than any one can presume to say. The impression left by English history on Jefferson is recorded in his declaration, that he would rather live without parliaments than without juries.

It is for the interest of the parties as well as of the public that a suit should be brought to a final termination as soon as a reasonable certainty for a correct decision has been secured. A government is bound to make its courts of original jurisdiction as good as, with reference to the circumstances of the case, it has the means of making them. That is the first and indispensable security. Supposing, nevertheless, that there are grounds for suspecting a failure of justice in any instance, on account of misdecision either upon the fact or the law, the course to be pursued depends on the stage which the proceedings have reached. There can be no reason for withholding from the original court, if it has still charge of the proceedings, the power of doing justice. This is done, in civil cases, in a court of common law, by means of a new trial. On the return of the record by the judges who were commissioned to take the trial at Nisi Prius, the court from which the record was sent can revise the law laid down at the trial by the presiding judge, and can also exercise a discretionary criticism on the verdict of the jury. In the event of the question being transmitted to a second jury, the judge commissioned to superintend, and the jurors summoned to rehear the facts, may be different individuals from those concerned in the former investigation; but the class which the inquest represents continues the same. It is not a superior court, but only another edition of the former. The judges on this occasion have frequently an opportunity of putting the parties to such terms as may appear to be advantageous to the ends of justice, especially with regard to the new evidence to be produced. It is a peculiarity belonging to the form of the action of ejectment, that a party may give himself the benefit of a new trial without the assistance of the court. In Lord Bath's case there had been five successive verdicts for Lord Bath before the House of Lords decreed a perpetual injunction. Justice Powell, in the year 1712 (1. Peere Williams, p. 212), observes that new trials from Nisi Prius are things of which he did not well know the foundation, but of which he had found the courts in possession. Judges of equity, possessing the whole case in their own hands, have allowed themselves a somewhat greater latitude of reconsidering and recalling their decrees, under the analogous forms of a rehearing and a bill of review. When an original court has once pronounced its final judgment, such a judgment is rightly made conclusive ever after, unless reversed by a higher court. There is sometimes the reality, and always the appearance, of hardship in binding the losing party to the possibly hasty or prejudiced opinion of a single tribunal. He will often be desirous of appealing elsewhere for the chance of its reversal. One chance of this kind, if the superior tribunal to which it is carried up is at all properly constituted, will be enough. This part of any possible judicial arrangement contains a choice of evils. Unless a power of removal or of appeal be given, one act of ignorance or of injustice will be fatal to the unlucky suitor. The other side of the risk is exemplified in the skeletons presented by the inferior courts for counties, hundreds, and baronies; or in a still more mischievous vitality. If the power is given, either both courts are really kept alive, in which case the temptation to run the gauntlet of both will often take a party through two proceedings, where he had much better have rested satisfied with one; or society and the law-books will be taxed with keeping up the cumbersome representation of a first court long after it has fallen into disuse. The differences between a writ of error from a court of common law and an appeal from the Court of Chancery are unimportant. They are the respective names by which the two systems mean the same thing. It is only upon appeals, in the spiritual court, that new evidence is received. The absurdity of the English practice, in marshalling appeals, consists not so much in its usually allowing an intermediate stage, as in its converting the whole nobility of the empire into the supreme appellate court. The barbarous incompetency of a tribunal of this nature is flagrant enough to satisfy the condition of raising an exclamation whenever it is mentioned; and it is neither removed nor concealed by the additional absurdity which, by way of a great constitutional improvement, imperatively requires at present, besides the one law lord who is to do the work, the ceremonial attendance of two suffragan peers in rotation for the purpose of looking on. A well considered reform has given the colonies and the spiritual courts an excellent court of appeal in the late judicial modification of the privy council. It is out of the question to suppose that suitors from the ordinary courts of the three kingdoms will rest contented without the benefit of some similar amendment in the character of the House of Lords as a court of justice. The scale of original and of appellate courts must be so constructed as to raise the presumption in favour of the latter. At present the appeal is carried from the most learned judicatures in the kingdom to one which necessarily knows nothing at all about the matter.

Criminal proceedings are carried on with or without a jury. The latter are called summary convictions. They were unknown to the common law. At present they take place in frauds on the revenue, and in many minor offences, before the particular persons appointed by the several statutes which have created these extraordinary jurisdictions. When the commissioner or magistrate has once pronounced his decision on the case as brought before him, he is *functus officio*. The privilege of appeal from his decision, in order to obtain a second inquiry into the merits, is not of common right; it only lies where it has been expressly given by act of parliament. The word is connected with the comparative novelty of the proceeding. For the word appeals had not passed beyond the spiritual courts until the time of James I. The earliest mention of appeals to the quarter-sessions is in the beginning of the reign of Charles II.; and towards the latter part of his reign they had come into general use. On the other hand, the writ of *certiorari*, by which the King's Bench removes before itself the proceedings of all inferior criminal jurisdictions, existed at common law. A certiorari has the object and effect of a writ of error, in an instance where, from want of learning, error was most likely to occur. For this purpose, whenever it is granted, the determination of the justices, like that of a jury in the case of jury-trial, is final as to the matter of fact; and the superior court, in reviewing their judgment, notices nothing but what appears upon the face of the conviction. The power of granting certioraris has been taken away by express statutory prohibition upon many occasions since the Revolution. Nevertheless the power is considered by the King's Bench as so beneficial to the subject, that the extent of these prohibitions is as much as possible restrained by the utmost jealousy of construction. A knowledge of law travels down to the quarter-sessions in the shape of opinions obtained from the metropolis, and in the persons of an attendant bar. If one or other must be dispensed with, it may perhaps therefore be fairly questioned whether the limited argument on a certiorari is not both more expensive, and at the same time less beneficial to the subject, than the more comprehensive re-investigation admitted upon an appeal. The conclusive nature of criminal proceedings before a jury depends on an absolute rule which the common law introduced, and which it has been able to preserve up to the present day in its own favourite tribunal. No man can be put in jeopardy twice for the same offence. As long as appeals for felony were in practice, this maxim might have been easily evaded. One precedent in direct contradiction to it is reported by Foster in the trials of the Jacobites. But when the jury has once been sworn on a charge within its jurisdiction, and upon a sufficient indictment, it is undisputed law that the prosecutor cannot elect to be nonsuited, and that there can be no second trial. The points on which a criminal judgment may be falsified or reversed by the King's Bench, or by the House of Lords, either with or without a writ of error, are all independent of the merits. Wherever the proceedings below are annulled on the supposition that the party prosecuted has never been tried at all, of course he still continues liable to prosecution in the same manner as if the former nominal trial had never taken place. The doctrine of attaints in criminal cases was at no time held in terror over a jury. At moments of violence, arbitrary judges, dissatisfied with a criminal verdict, formerly imposed fine and imprisonment instead. This was equally unjust, and was illegal into the bargain. In the nature of things, however, there can be no reason why the presumption in favour of the correctness of a verdict should be placed higher in criminal cases than in civil. Yet the one is left carefully open to revision, while the other is as carefully closed. The distinction is partly the result of accident, partly of indifference. But it is probably in some degree to be attributed to the fact that it was an object to bring litigation sooner to a close, where, owing to the poverty of the parties, and to the rules concerning the costs of an indictment, the litigation would be prolonged at the expense of the public.

The present popularity of the distinction is undoubtedly for the most part matter of tradition. The cause of it is to be found in the despotic practices of former times. The people gladly acquiesced in any rule which lessened the number of criminal prosecutions, and secured to a defendant the whole advantage which had been hardly earned for him by the rare contingency of a courageous jury. It is impossible that even the violent condition of unanimity can make the first impression of any court, especially of a court constituted like a jury, so completely satisfactory that the conclusiveness of a single verdict can be consistent in all criminal trials with the ends of justice. The rule in the present state of society operates entirely in favour of the prisoner. It must do so as soon as the crown has learned to exercise the prerogative of pardon on purely public considerations. Amongst these, and in the first rank, stands the necessity of protecting the conscience of mankind against the possible suspicion of punishing the innocent. If there has been any mistake in fact or in law, or if any fresh evidence has come to light, the prisoner is certain of receiving from the executive the full benefit of the discovery, in mitigation or pardon. On the other hand, unfounded acquittals are very injurious to the best interests of a community. They turn back on society offenders whom impunity has hardened. They embolden all who are tempted by vicious propensities to prey upon the public. They bear down the innocent man's appeal to a verdict in vindication of his character, by the cry of acquitted felons. They destroy the confidence of the people in the truth and efficiency of the law. The ancient scruples, by which the statutes of *jeofails* were not allowed to amend errors in indictments, had no connection with truth, justice, or sound humanity. As little can be said in behalf of any scruple which refuses society, for the punishment of a wrong-doer, the same assistance as it affords a private individual in satisfaction of his private injury. It will not be to the credit of the reason and the temper of the English public of the present day, if they are not able to remove this inconsistency between the two systems, by the interposition of checks and precautions, which, whilst they give a proper chance of justice to the public, shall secure a prisoner against any further hardship than that of having his case properly decided.

8. *Judicial Proceedings.*—On these points the English practice bears a remarkable resemblance to the Roman in some particulars, which have been comparatively abandoned in countries where otherwise the civil law is the principal authority. It is the more curious to find these coincidences between two systems, which are otherwise so different, that Selden observes they have not a term in common. The original writs of the common law, by being the tests whether a party has or has not a right, are rude approximations to a code. Their analogy to the set forms for actions adopted by the Romans is so striking, that Duck and Noy agreed that the writs in the *registrum brevium* must have been settled by great civil lawyers. Blackstone (vol. iii. p. 117) speaks as if some similar standard was in itself undoubtedly necessary to fix the true state of a question of right; and he even subjoins, that an equivalent method is recognised by all the modern legislatures of Europe. This is surely a proposition very difficult to be maintained in the presence of the contrary experience, both of Scotland, and of the English courts of equity and of Doctors' Commons. In the subsequent proceedings, most judicatures leave the parties to tell their story in their own fashion. But Mr Stephen, in his excellent work on pleading, shows, by reference to Quinctilian's account of the method of oratorical analysis, which he himself used in forensic controversies (B. vii. c. 1), how artificially the logic of a Roman advocate was directed to the object of bringing out the point in issue. Looking at the different ways in which the testimony of witnesses may be extracted, Mr Bentham says that cross-examination is, both in the thing and in the name, peculiarly English; for every thing of the sort is excluded by the interchange of written interrogatories from the present usage and vocabulary of the civil law. However, in the seventh chapter of the fifth book of his Institutes, Quinctilian has again sketched as accurate a picture of examination and cross-examination as a Nisi Prius leader could desire. Every rule of positive law is necessarily founded on a balance of advantages and disadvantages. In many cases the line of prudent compromise between opposite mischiefs is extremely difficult to draw and to preserve. Wherever the line is taken, nothing is so easy or so unreasonable as to caricature it, by representing only the inconveniences which every compromise assumes. This is particularly true with regard to judicial pleadings. They are merely the statement made by both sides of their case; nevertheless they are a subject which, on account of the opposite mischiefs of the Scottish and English systems, has lately been the occasion in both countries of elaborate debate and judicious propositions for their reform. The nature of the mischiefs in these two instances is just the reverse of what might have been expected. Scotch pleadings, which were carried on under the superintendence of the judge, erred by extreme looseness; whilst English pleadings, which, except in extreme cases, had been for ages left to the discretion of counsel, became celebrated for the characteristic error of an extreme strictness and technicality. The intermediate course taken by the Court of Chancery appears upon the whole to be the most rational; though equity drawing has quite reproach enough in its verbosity and repetitions, where every word has a pecuniary value. As soon as the new rules relating to pleadings, which have been lately framed by the judges of the superior courts of common law, shall have come into practice, it may be confidently trusted that the common law will no longer labour under the evil of voluminousness, in addition to that of technicality. Originally, parties made their statements to the judge by word of mouth, with as little form as a complainant tells his story to a magistrate, or as counsel at present open the case orally at the bar. During this period a great deal would depend on the talents of the judge for abridging irrelevant details, and clearing up ambiguous expressions. Afterwards, towards the middle of the reign of Edward III. when writing became common, the substance of the altercation, to which the evidence and the argument were to be applied, was required (and very properly) to be put down in writing in the first instance. The moment of this transition was the golden age of English pleadings. Serjeants drew them, and judges settled them. The judges ceased by degrees to interpose at this early stage of the suit. But, according to the scholastic subtilties of that age, the science of special pleading was encouraged to become more minute and complicated. A proportionate degree of technical knowledge was rendered necessary for the judge, since he had ultimately to award the prize to the professional combatant who had manœuvred on behalf of his client with most success on this preliminary arena. Fitzherbert, Littleton, and Coke expatiate on the learning, the lucrativeness, the honour, and delights of pleading. The reports of Chief-Justice Saunders are the glory of this art; and his mind is a model of the sort of astuteness which it cultivates. The department calls for but a small, and that far from the highest, portion of real judicial ability. It becomes only prejudicial craftiness the moment that it passes the boundaries within which a strong and logical understanding would confine

the speeches of advocates at the bar. The degree at which an intimate acquaintance with special pleading still ranks in the list of qualifications for the bench, is a proof how much that boundary has been overpassed.

Besides mastering the merits of his case, formal difficulties of great magnitude are in this early stage of the inquiry thrown upon an English lawyer. In the first place, he has to select the appropriate form of action; and having done that, he must comply with the established principles on which the forensic argument is to be conducted, and which, *mutatis mutandis*, are equally applicable to all forms. Our historical sketch of the transitions of English pleadings shows what alone they ought to be when they are properly considered. If they are nothing but the statement made by the parties, of their respective cases, What is the only object of an intelligent and honest statement? It can be nothing else than to keep clear of extraneous topics, and to get to the point in dispute as soon as possible. As every legal question consists of the application of a supposed principle of law to some one or other supposed fact, the first thing to ascertain is, About what are the parties quarrelling? Do they differ in their view of the law or of the facts, or both? The alternative cases present no difficulty. When there is no dispute about the facts, there is a simple point of law for the opinion of the judges. It is at once raised upon what is called a demurrer. On the other hand, when the dispute turns entirely on the facts, what is wanted, is, that they be brought out to the jury in so precise and definite a shape, that it is impossible to mistake the point or points in issue. If the party is prepared to dispute the correctness of the law as applied to the supposed facts, and further, also the correctness of the facts as stated, questions of considerable difficulty and difference of opinion open on him. Must he enter upon both issues simultaneously? or may he take first one, and then the other? and, in the latter case, with which of the two issues, that of fact or that of law, ought he to begin? The English common law disposes of these considerations by summarily making an admission of the facts a condition of a demurrer. A legal proposition can seldom be put forward so manifestly erroneous that a defendant will not think it advisable to retain both chances in his hands. It is on the facts, namely, what he should prove, concede, deny, that he must be careful to watch over his own interests. Points of law will comparatively take care of themselves, and the benefit of these is also secured at all stages. Demurrers are freed in courts of equity from the above condition. The experience in equity by no means justifies the apprehension entertained by the common-law pleaders, that on the removal of the condition every cause at common law would be forthwith burdened with a tentative demurrer. The discretionary application of costs might easily be made a most effectual instrument for the suppression of such unwarrantable speculations as might at first arise upon a relaxation of the former rule. The abuses of special pleading have on many occasions induced the legislature to interpose. Particular defendants, as magistrates, for instance, have been favoured, by way of exception, with the privilege of pleading the general issue; that is, they are allowed to deny generally the wrongful act imputed to them, without being called upon to state whether they mean to deny the law or the fact, or to mention a single item of the hundred possible special grounds of their defence. The English system prides itself on its peculiar mechanism, every movement of which necessarily tends to a clear and single point. The plea of the general issue does much more than lose the advantage for which so much is sacrificed. It covers every thing with a cloud. It gives the defendant the privilege of evading the duty of speaking out, by adopting a common form, which tells the opposite party absolutely nothing. The regulation which refuses a prisoner a copy of his indictment till he holds up his hand to take his trial, is scarcely in principle more unjust. Fraud lies in generalities. On the one hand, a defendant or a prisoner has a right to know the particulars of the demand or of the accusation brought against him; something more than the mere assertion, that he is liable to a demand or charge of some sort; what it is being left to appear on the day of trial. On the other hand, plaintiffs and prosecutors are equally entitled to know beforehand the particulars of the defence on which their claim is to be resisted; something beyond a direct negation. At all events, when the power of pleading the general issue is thrown over a party as a shield, the exception should rest on the nature of the case, and not on the authority of the person. A better distinction might be found than that of official station. Pleadings drawn up and communicated by the professional representative of the parties ought to contain a correct narrative of the transaction in writing. Thus prepared, they might be expected to be more complete, and at the same time more relevant and more concise, than any judge could have obtained from their own mouths if present. Yet what would be thought of parties in open court who were to ramble into the jargon and exaggeration of a declaration; or who should indulge themselves *viva voce* in the fiction of alleging the utmost preciseness of time and place, whilst every syllable of the allegations was perhaps notoriously and ridiculously untrue. It is difficult to account for the origin of such extravagant falsehoods. They are as indefensible in point of reason, coming from the pen of a pleader, as if they came from the principal himself, preferring his claim and conducting his cause in person.

9. *Evidence.*—What the pleadings have stated, it is the object of evidence to establish. One of the most difficult things to account for, is the absurdity of the rules of judicial evidence, which have prevailed in all ages and over all countries. Sir William Jones observes, in his preface to Isæus, that "we may triumph in our elegant and philosophical theory of evidence, which Aristotle and Plato must have admired, and by the strict rules of which all trials in the world ought to be directed." No panegyric was ever less deserved. It is perhaps true that the English theory on this subject is less objectionable than the theory of almost any other country, inasmuch as its exclusions appear upon the whole to be fewer and more strictly limited. But it is faulty enough even in this respect; whilst whatever other defects may be found incorporated in its principles, they are likely to be felt more severely in practice, in consequence of the unbending rigidity with which every rule is enforced by English lawyers. Our judicial system is too careless in requiring or preserving preconstituted written evidence, even in the case of recurring events and deliberate transactions. The registries of baptisms, deaths, and marriages, are still left as a part rather of ecclesiastical discipline than of civil obligation. They are exposed to great irregularities and losses, whilst a general registry of deeds remains yet to be established. In criminal proceedings the attendance of witnesses on both sides is secured by summary methods. The duty of appearing for a prisoner as well as against him is equally a debt due to society by its members; although it is one which the law was disgracefully slow in recognising. In civil cases witnesses are obliged also to attend; nor can they insist upon more favourable terms than the tender of their expenses. The English law admits of four heads of personal incompetency in a witness: one intellectual, as want of sufficient reason; and three moral. Of these, the first is a want of religious belief, extending as far as to disbe-

lieve the existence of a God and of a future state of rewards and punishments. The second is infamy of character, evidenced by a judgment of felony, or for some offence considered by the law as infamous. The last is, a direct legal interest in the cause at issue, or in the question asked. The objection that the witness might use the verdict upon some future occasion, has recently been removed. The only head of incompetency from family relationship, is the case of husband and wife. It applies to both, and to evidence offered either for or against each other. The only instance of incompetency from professional relationship, is the rule by which a lawyer is prohibited from giving evidence against his client concerning any facts with which he has become acquainted under the sanction of that relation.

The objections are equally fatal, whether the acts to which the testimony applies are sudden or deliberate. It would be as difficult to justify the want of distinguishing between these two classes, as to prove the propriety of the distinctions which, in some instances, prevail between the admissibility of the same evidence in criminal as in civil proceedings. The rejection of hearsay is also too extensive. It may be doubted whether the rejection should ever be carried further than to declarations made by a person whom it was possible to have produced as a witness, and who might have been compelled in the character of a witness to repeat his supposed statement under the sanction of an oath or other solemnity, and subject to cross-examination. It does not apply to declarations, themselves a part of the transaction. The tendency of the judges of latter days has strongly run in the direction of letting in evidence. But more extensive innovations upon the former exclusions than the judges feel at liberty to authorize are probably near at hand. Amongst these, the taking away the exclusion on the ground of interest in a civil suit, is the most important. There can be no doubt but that the examination of a prisoner, humanely conducted, would be very favourable to truth. But there is much doubt whether even an open court could be trusted with the authority, and still more whether the public would be satisfied with the change. All the objections above enumerated go to the competency of a witness, and, where they apply, are fatal. All other objections are of minor consequence. They go only to the credit, and as such, they are questions, not of total exclusion, to be determined by the judge; but matter for observation, turning on degrees of credit, more or less, to be weighed by the jury. Two witnesses, or an equivalent, are universally required by the civil law. With us, one witness, if believed, was sufficient for all purposes, until parliament made two necessary in treason, and until a rough sort of comparative arithmetic established the demand for something more than a single witness upon a charge of perjury. Parliament has insisted upon the aid of three witnesses to a will devising an acre of land, though a million in the three per cents. may be bequeathed by an unwitnessed testamentary paper. Courts of equity have imposed a limit on their encroaching jurisdiction, by allowing the positive oath of a defendant to be conclusive against the unsupported testimony of a single witness. The limit has probably a reference to the double origin of Chancery; first as a court of conscience, and next as more closely connected with the civil law. There are but few instances, and those introduced by act of parliament, where written evidence is of absolute necessity. The policy of the celebrated statute of frauds was adopted from the French ordonnance of Moulins; and it admits of no exceptions where it applies. But writing is often used by the parties in transactions which are without the statute. The common law is equally strict in both cases, in preventing written instruments from being varied, added to, or explained by *parole*. The rule has been broken in upon to a certain extent, by a distinction between *ambiguitas patens et latens*, of which Lord Bacon has the credit. The best justification to be made for the exception which allows an ambiguity raised by external evidence to be also removed by external evidence, appears to stand on the following considerations. It restrains the fear of perjury within a much narrower circle. In the next place, the author of the writing had not equal means of protecting his intentions against an ambiguity of this description. The admissibility of copies is tried by the paramount rule, that the best evidence in existence must be produced. Mere declarations acquire no further validity by being committed to writing. They thus become only written hearsay. The mode of extracting oral testimony varies according to the courts in which it takes place. Very little can be added to the excellence of the system in the courts of common law. A witness there delivers his evidence *viva voce*, in the presence of the public, of the parties, and of the deciding judge. There is scarcely a limit to the range of examination and cross-examination, but the discretion of the court. The practice in courts of equity is much more imperfect. The examination being conducted on written interrogatories, and by examiners out of court, loses all the advantages of *viva voce* suggestions on the spot, of cross-examination, and of publicity. The very demeanour of the witnessess is removed from the observation of the judge who has finally to determine on their credit. The proof of writings depends on the nature of the instrument, or on the mode of its execution. The English law does not affect to create a scale by which the value of particular evidence may be determined. With the same forbearance, it has refrained from establishing any judicial standard concerning the amount of evidence which is or is not adequate grounds for a judicial determination in any cause. These are questions of fact, on which (beyond a few hints, more valuable to a committing magistrate than to the deciding judge) the less that is said in law-books the better. The only security for correct decisions is the founding competent tribunals, and binding them to no other criterion than that of their own personal conviction. Mr Bentham's work on evidence, and his criticism on this branch of the English law, are perhaps the most original, and at the same time most useful, of all his writings.

10. *Judgment and Execution.*—The object of a civil action is either the recovery of a right certain, for instance, particular lands, specific goods, a fixed sum as settled by the agreement of the parties; or the recovery of uncertain damages, more or less, according to the extent of the injury which the plaintiff shall be able to prove that he has sustained. The first class of cases, by the nature of the demand comprehended in it, relieves the tribunal from the vague and discretionary inquiries arising under the second. The amount of damage is a fact which a few impartial individuals taken from the body of society are in the great majority of cases peculiarly qualified to assess. This in civil actions is accordingly the province of the jury. They are likely to be far better acquainted than learned judges with the real elements on which the calculation ought to proceed. Damages evidently so excessive as to be explained only by the imputation of gross ignorance or corruption, are, however, one of the admitted grounds for sending back the case to a second inquest. The judgment against Titus Oates, for *scandalum magnatum*, at the suit of the Duke of York, where one of the juries of those days had assessed the damages at L.100,000, was reversed after the Revolution. The costs of a trial were never given at common law. In most cases, however,

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they have for a long time followed as the ordinary incident to judgment. Since the preliminary oaths and pledges of former days have fallen into oblivion, they constitute the only security of the defendant against frivolous and vexatious actions. Costs are too material an item in litigation to be properly bound in any court by one uniform rule. We are not disposed to recommend, for the sake of consistency, that courts of equity should be brought under the strictness. It would be a better approximation that the discretion of the courts of common law should be assimilated to the latitude which courts of equity have assumed. It is easy to enlarge the statutory power given in some instances to judges' certificates, or to grant an analogous authority to the jury. Certificates for costs might be made a sufficient restraint on fraudulent attempts against the credit of the law and the interests of society. There are occasions when personal vindictiveness combines unnecessarily an indictment and an action in misdemeanors, or when base practitioners multiply actions for the sake of costs against several parties who happen to be all legally liable. In ejectments, trespasses, libels, joint-stock companies, and all cases where many rights depend upon a single title, or the ends of justice may be satisfied by a single verdict, the law in its present state may be far too easily and too profitably abused.

In consequence of the feudal restraints on the alienation of land during a great period of English history, it continued to be only partially liable for its owner's debts of any description, and was not liable at all for ordinary debts by simple contract. The restraint went far beyond the policy of entails. To the extent that entails were permitted, a tenant for life might, as far as the principle was concerned, have bound the life estate, but nothing more; since that only is his own. This invidious protection of land, even when owned in fee against simple contract creditors, has been completely removed during the last session. Ever since the 29th Charles II., whenever land was at all liable, it was equally so although held in trust for the debtor, as when it was held in his own name. No feudal principle interfered to protect personalty from a creditor. Nevertheless, the absurd expression, that money cannot be sold, and the maxim, so inconsistently evaded in many cases, that a debt or a right to sue another was not transferable, had an equally mischievous effect. No sensible reason can be assigned why the principle of foreign attachment should exist for the benefit of the citizens of London only, and not for the benefit of every creditor in England. There is even still less reason why funded property should be placed beyond the reach of the law, on the technical distinction arising from its subsisting in the form of an annuity payable by the nation to the holder of the stock. The bank, in the management of this property, is a parliamentary trustee for the owners of it. And the judgment of a court of law, duly certified on a recovery against a stockholder, ought to have the same effect as the signature of the accountant-general of the Court of Chancery for authorizing a transfer of the stock. There is a dangerous tendency in facilities for credit to run to too unlimited an extent. The power of imprisoning the person encourages this tendency; and, what is worse, it is frequently resorted to in the hopes of laying the innocent relations of a spendthrift under contribution. The humanity of modern times has thrown open the doors of the debtors' gaol, by discharges under the insolvent act. The security contingent on the person of a debtor was good for much at no time. In its actual state, it is of far too little value to be worth contending for. It is likely to be soon reduced to nothing, since it is seriously proposed, on grounds of public policy, to prohibit altogether imprisonment for debt.

For the prevention of crimes, the law seeks to obtain a counteracting influence in all directions; in its command over property, character, liberty, and life. The jury find merely the fact of guilt. The legislature has to most offences affixed a *maximum* of punishment, according to a rude calculation of the nature of the offence and the interests of society. In a very few a *minimum* also is enacted. The power of arbitrating between these extreme limits, and of mitigating the penalties where no limit has been prescribed at the bottom of the scale, rests entirely with the judge. The gradation of punishments seems to call for further revision, with the object of proportion, mitigation, and precision. The calculation of public damage proceeds on the principle of prevention, and is set apart for the judge; that of private damage looks only to the satisfaction of the party, and belongs to the jury. The distinction arose probably on totally different grounds. It may be justified, however, by the observation, that the calculation in the instance of crimes does not depend on the individual case, but on a more comprehensive and general view of the bearings of the whole criminal law than a jury can well be qualified to take; and that a greater chance is thus afforded of an approach to that uniformity or average which it is so desirable to obtain. Pardon is a prerogative properly left with the executive. This is so in America, notwithstanding the foolish denial of the possibility by theoretical writers against republics, equally as in England. The exercise of the prerogative is of course greatly influenced by the recommendation of either the judge or jury. The abuse of it in favour of particular criminals was one of the scandals of many reigns. This had reached so extravagant a pitch, that Sir Thomas More praises Henry VIII. on the ground that never king granted so few. Nevertheless, such was the complication and severity of the law, that to execute it according to its letter would have been not only unpopular, but impossible. At the very period when particular pardons were a national grievance, general pardons were looked forward to as public blessings. It is observed by Sir Bartholomew Shower, that there were never five years without a parliament pardon, and that eleven were published by Elizabeth. "These," he says, "it was which made parliaments and crowns the darlings and the desire of the people." The dispute whether the crown can pardon on impeachments, was one of the remains of the jealousies of former days. It was raging, as a great political question, as late as the Revolution; and it is still open to argument as a point of law. The dissolving parliaments to save his favourites from impeachment, is charged even by Clarendon upon Charles I. as a denial of justice to the nation. There is a vast variety of writs of execution in civil suits of the most trifling moment. By way of contrast, Blackstone notices the slightness of the form by which a marginal note put by the judge upon the calendar, is the sole authority for the sheriff, even in a capital conviction. It is one only of many instances of the comparative value set by our ancestors on the formal administration of civil and criminal jurisprudence. The execution of the law in all cases, of whatever description, is intrusted to the official representatives of the executive. Special jurisdictions have their special officers; but, by the common law, the sheriff is in all judicial matters the proper minister of the crown.

ENGLISH LANGUAGE. When the Romans invaded the south of Britain, they found the country possessed by a people of Celtic origin, and speaking a dialect of the Celtic tongue. This invasion took place about fifty-five years before the birth of Christ, and the invaders retained their ascendancy till the commencement of the fifth century. During this interval, the Romans imparted to the rude natives some tincture of their own intellectual refinement, but must have left the British language as they found it: the foreign settlers were not sufficiently numerous to produce any change in the speech of the original inhabitants. When the huge fabric of the Roman empire began to decay, the Britons, who had the advantage of a remote and insular situation, found means to assert their independence. They however divided themselves into many petty states, and exercised many petty animosities, which impaired the national strength, and rendered them an easy prey to foreign invaders. The pirates of Saxony had long been accustomed to make occasional depredations on their coasts. The Picts and Scots, that is, the Goths and Celts of North Britain, infested them on the frontier; and at length the sense of common danger produced some degree of union in their councils and exertions. In this condition of their affairs, the Saxons obtained a permanent footing in the country. In the year 449, Vortigern, king of the Britons, had recourse to the aid of Hengest and Horsa, who first appeared as allies, but were soon converted into the most formidable enemies.[1]

The Saxons, like other Gothic tribes, derive their origin from a mighty horde which wandered from the east, and gradually overran the best portions of Europe. So early as the time of Ptolemy the geographer, this particular tribe had proceeded as far to the westward as the banks of the Elbe, and their primitive seat was between that river and the Eyder. Although at first they were not very formidable for their numbers, they gradually obtained a powerful ascendancy in Germany. Towards the middle of the third century, they entered into a league with the Franks for the purpose of opposing the Roman arms; and they afterwards enlarged their connexions and increased their influence till it predominated in a territory of great extent, reaching from the Eyder to the Rhine. This wide tract of country was not entirely peopled by Saxons: it included various nations, united by the ties of a kindred origin, and actuated by a sense of common interest or danger; but such was the ascendancy of the Saxons that they communicated their name to the entire confederacy, which, among other nations, comprehended the Jutes, who inhabited the south of Jutland, and the Angles, who inhabited the adjacent district of Anglen. Hengest and Horsa, the leaders whom we have already mentioned, were not Saxons, but Jutes. The subsequent emigrants were for the most part Angles, and their descendants were long distinguished by the name of Anglo-Saxons. The first part of the name denotes the predominant tribe, the second denotes the original relation of that tribe to the Saxon confederacy. The new country which they acquired was denominated Engla-land, or the land of the Angles. These German invaders established themselves in the most fertile districts, and gradually displaced the Celtic inhabitants, till at length they were chiefly confined to the fastnesses of Wales, where the prevalence of the ancient language still indicates the continuance of their race. Eight new states were formed by the Anglo-Saxons, who maintained their independence till the year 1016, when they were subjected to the yoke of a Danish conqueror. Canute, and his two sons, Harold and Hardicanute, reigned in England for the space of twenty-six years. A Danish court, and a Danish army, with other settlers, must have had some influence on the common speech, especially as the language of the conquerors was not very dissimilar to that of the conquered. But the laws and other public documents continued to be written in the Saxon tongue, and this new dynasty soon finished its course. The Saxon line of kings, which was restored in 1042, terminated in 1066, when Harold the Second was slain at the battle of Hastings, and William duke of Normandy ascended the throne of England. The Saxon dominion had thus continued for the best part of three centuries; and as the great body of the people was still of this race, it is obvious that their national language must have survived their political power. A writ in the Anglo-Saxon tongue was issued by Henry the Third, who began his reign in the year 1216.

In the language spoken by this ancient people, a great variety of literary reliques has been preserved. "The Anglo-Saxon literature," says Professor Rask, "possesses in many respects, even for its own sake, no small degree of interest. The numerous ancient laws throw considerable light upon the laws of the old Germans and Scandinavians, as well as upon their customs and civil institutions. The old chronicles and genealogies are important sources for the ancient history of the Low German and the Scandinavian nations. The various documents illustrate much in English history. Even the theological remains, shewing the constitution and doctrine of the ancient church, are not devoid of value for ecclesiastical history, especially to the modern English and Scottish churches. The translation of several parts of Scripture may likewise be advantageously employed in biblical researches. But of all, the poetical pieces are the most interesting, especially the great Anglo-Saxon poem in forty-three cantos, published at Copenhagen in 1815, by the Royal Archivarius G. J. Thorkelin,[2] which, from its commencement, he has aptly entitled *Scyldingis*. This is perhaps the only Anglo-Saxon piece possessing value on account both of its matter and style, particularly for the nations of the north; the principal hero being Swedish or Gothic, though the action lies in Denmark."[3] This ancient poem, more generally known by the name of *Beowulf*, has been translated into Danish verse by Dr Grundtvig, and ably illustrated by Mr Conybeare.[4]

The language of the conquerors became the language of the king's court and of all the courts of law. The pleadings of counsel and the decisions of judges were couched in a dialect which is commonly described as Norman French, but which in the mouths of English lawyers became utterly barbarous; and more curious specimens of composition are scarcely to be found than those which occur in the reports of cases written in a jargon half-French half-English. Lawyers have in all ages been conspicuous for their stiff adherence, with or without reason, to those forms and maxims in which they themselves have been duly trained. Long after French had ceased to be the language of legal proceedings, they adhered to the practice of reporting cases in the motley dialect used by their predecessors; for, as Blackstone remarks, "the practisers being used to the Norman language, and therefore imagining that they could express their thoughts more aptly and more concisely in that than in any other, still continued to take their notes in law French; and of course, when those notes came to be published, under the denomination of reports, they were printed in that barbarous dialect; which, joined to the additional terrors of a Gothic black letter, has occasioned many a student to throw away his Plowden and Littleton, without venturing to attack a page of them."[1] By the 36 Edw. III. c. 15. it was enacted that for the future all pleas should be pleaded, shewn, defended, answered, debated, and judged in the English tongue, but should be entered and enrolled in Latin. The statutes of the realm long continued to be promulgated in French; and it was only from the accession of Richard the Third that Englishmen were governed by laws written in their native tongue.

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[1] Saxon Chronicle, p. 14. Ingram's edit. Lond. 1823, 4to.

[2] A more recent edition may be found in an elegant little volume bearing the following title: "The Anglo-Saxon Poems of Beowulf, the Traveller's Song, and the Battle of Finnes-burh: edited, together with a glossary to the more difficult words, and an historical preface, by John M. Kemble, Esq. M. A. of Trinity College, Cambridge." Lond. 1833, 8vo.

[3] Rask's Grammar of the Anglo-Saxon Tongue, translated from the Danish by B. Thorpe, p. vii. Copenhagen, 1830, 8vo.

[4] Conybeare's Illustrations of Anglo-Saxon Poetry, p. 30. Lond. 1826, 8vo.

The Norman conquest proved fatal to the entire race of Anglo-Saxon nobility, many of whom lost their lives, and almost all of them their property. Not a few of the number sought refuge in different monasteries. Some of them became abbots, and others closed their career as monks. The lands of the Saxon earls were occupied by the Norman barons, who found it necessary to consult their personal safety by inhabiting fortified towns and castles. They must have had but little intercourse with their vassals, whom they probably did not respect, and whom they had much reason to fear. They retained their native tongue, and seldom acquired any other. For a long period of time, the peasantry continued unmixed with foreign settlers: they continued to cultivate the same soil; and when the written language of the kingdom had received many foreign accessions, the rustic dialect preserved its primitive elements with very few material changes. Much of the patois of different countries consists, not in adulterations of the modern, but in remnants of the ancient language. Many Anglo-Saxon words and idioms, unintelligible to persons of a refined education, are still current among the rural population of particular districts of England.

The English monarchs of the Norman race were liberal patrons of such literature as they themselves understood. French poetry seems to have been much relished at the court of England; and, according to a very competent judge, M. de la Rue, it was from England and Normandy that the French received the first works which deserve to be cited in their language. The works of many Anglo-Norman poets have been preserved, and they certainly form a curious subject of literary research. In this department, a learned lady, Marie de France, makes a prominent figure. Her poems have been recently edited by M. de Roquefort; and one of the historical poems of Wace still more recently by M. Pluquet. A history of the Anglo-Norman poets and poetry is speedily expected from M. de la Rue, who has already exhibited sufficient evidence of his being well qualified for such an undertaking.

Of the language spoken by the great body of the people about a century after the conquest, the reader may in some degree be enabled to judge from the following specimen of Lyamon's translation of Wace's *Brut d'Angleterre.* The translator describes himself as a priest of Ernlye upon Severn, and he is supposed to have completed his task about the year 1180.

Tha the masse wes isungen,
Of chireeken heo thrungen.
The king mid his folke
To his mete verde,
And mucle his duȝethe:
Drem wes on hirede.
Tha quene, an other halve,
Hire hereberwe isohte:
Heo hafde of wif-monne
Wunder ane moni en.[2]

"When the mass was sung, out of the church they thronged. The king amid his folk to his meat fared, and many of his nobility: joy was in the household. The queen, on the other side, sought her harbour (or lodging): she had wonderfully many women." Here, and in a much more ample specimen of the same work, we perceive no mixture of French words. The idiom is essentially Anglo-Saxon, but with some indications of its being already in a state of transition: the vestiges of the language, in its more modern form of English, may be distinctly traced. Of the language in a state more considerably advanced, we find a specimen in a facetious poem published by Dr Hickes.

Far in sea, by West Spain,
Is a land ihote Cokaygne,
There n'is land under heaven-rich
Of wel of goodness it y-like.
Though Paradise be merry and bright,
Cockaygne is of fairer sight.
What is there in Paradise
But grass, and flower, and green rise?
Though there be joy and great dute,
There n'is meat but fruit;
There n'is hall, bure, no bench,
But water mannis thirst to quench.[3]

In this poem, which apparently belongs to the thirteenth century, we perceive a further deviation from the Anglo-Saxon idiom. In the preceding extract, the obsolete spelling is not retained, and the language is thus rendered more intelligible. The subsequent quotation is from a metrical history of England, written by Robert, a monk of Gloucester, who appears to have lived about the year 1278. This rhyming chronicle, as Mr Warton has remarked, is totally destitute of art or imagination. The author thus describes the island of Ireland, nor does he fail to mention its exemption from venomous reptiles.

Yrlond ys aler yle best with oute Engelonde.
The sea goth al abouten hym eke as ich vnderstonde.
More he ys than Engolond, and in tho south half he ys
Bradder and more of ynow than in the north ende y wys.
Aȝeyn the lond of Spayne he stond in the north syde ryȝt.
Selde snowe ther inne lith, and nameliche thre nyȝt.
So euene hot that lond ys, that men durre selde
Here orf in howse awynter brynge out of the felde.
Lese lasteth ther al the wynter: bute hyt tho more wonder be,
Selde me schal in the lond eny foule wormes se:
For nedres ny other wormes ne mow ther be noȝt;
And ȝef he beth thider bi cas from other landes y broȝt,
Heo dyeth thorȝ smel of the lond, other thorȝ towchyng y wys:
Eche gras that ther inne wexeth a ȝeyn venym yt ys.
For men that ben venymed, thorȝ grases of Yrlond
Y dronke he beth y clansed sone, thoru Godes sonde.
Hony and mylk ther ys muche, mony folk and bolde.
This ys the stat of Yrlond, as iche habbe y tolde[4]

Another chronicler, who however belongs to a period somewhat more recent, was Robert Manning, more commonly called Robert of Brunne. He has himself stated that he had resided fifteen years at Brunne, or Bourne, in the priory of black canons, when, in the year 1303, he began his translation of Grosteste's *Manuel des Pechés.* This version still continues in manuscript; but one portion of his historical work, his translation from Langtoft, has been edited by the indefatigable Hearne, who rendered a similar service to Robert of Gloucester. The inedited portion consists of a translation from Wace's Brut. Peter Langtoft was an Augustine canon of Bridlington in Yorkshire, and is supposed to have died in the reign of Edward the Second. The subsequent passage relates to Sir William Wallace.

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[1] Blackstone's Commentaries on the Laws of England, vol. iii. p. 318.
[2] Ellis's Specimens of the Early English Poets, vol. i. p. 61.
[3] Hickesii Linguarum Vett. Septentrionalium Thesaurus, tom. i. p. 231.
[4] Robert of Gloucester's Chronicle, vol. i. p. 43.

Whan Sir Jon of Warene the soth vnderstode,
That the Waleis gane brenne, an oste he gadred gode,
And went to Struelyne agayne Waleis William,
Bot the erle with mykelle pyne disconfite away nam;
And that was his folie, so long in his bed gan ligge,
Untille the Waleis partie had vmbilaid the brigge:
With gauelokes and dartes suilk ore was non sene,
Myght no man tham departe, ne ride ne go bituene.
Thore first tham tauht how thei did Fawe kirke:
Alle gate the brigge he rauht, of nouht our men were irke.
Whan the erle herd say, the brigge how William toke,
He douted to die that day, that bataile he forsoke.
The Inglis were alle slayn, the Scottis bare tham wele,
The Waleis had the wayn, als maistre of that eschele.
At that ilk stoure was slayn on our side
God men of honour, that wald to the bataile bide.[1]

A more curious specimen of composition is to be found in the Vision of Piers Plowman, which appears to have been written about the year 1362, and which is commonly ascribed to Robert Langland, a secular priest. The work, which comprehends a series of visions, is replete with satire on the different orders of men, especially on the clergy, both regular and secular; but it is likewise diversified by a succession of incidents, and furnishes abundant evidence of the author's talents for description. His mode of versification is not unworthy of particular notice. Alliteration supplies the place of rhyme: the corresponding sounds are at the commencement, not at the termination of words. Our extract from this remarkable work must necessarily be very brief.

And to the church gan ich go, God to honourie,
By for the crois on my knees knocked ich my brest,
Sykinge for my sennes, segginge my pater noster,
Wepyng and wailinge tyl ich was a slepe;
Thenne mete me moche more than ich by for tolde
Of the mater that ich mete fyrst on Malverne hulles.
Ich sawe the feld ful of folk fram ende to the other,
And Reson revested ryght as a pope,
And Conscience his cocer by fore the kynge stande.
Reson reverentliche by for al the reame
Prechede and provede that thuse pestilences
Was for pure synne to punyshe the puple,
And the south west wynd on Saturday at eve
Was pertliche for prude, and for no poynt elles.
Piries and plomtrees were poſſed to the erthe,
In ensample to syggen ous we sholde do the betere:
Beches and brode okes weren blowe to the grounde,
And turned upward here tayl, in tokenynge of drede
That dedlych synne er domys day shal for do us alle.[2]

After these specimens of verse, we shall exhibit a specimen of prose, selected from the seventh chapter of the Acts of the Apostles, as translated by John Wycliffe. The translator, who was born about the year 1324, and died in the year 1384, may be regarded as the father of English prose. He was the author of various works in Latin as well as English; but the most important of his literary labours was a complete version of the Scriptures. He was the great precursor of Luther, who appeared after an interval of one hundred and fifty years; and it may perhaps be safely affirmed, that to him the cause of reformation was more deeply indebted than to Luther himself.

"This Moises ledde hem out, and dide woundris and signes in the lond of Egipte and in the Reed See, and in desert fourti gheeris. This is Moises that seide to the sones of Israel, God schal reise to ghou a prophete of ghoure britheren; as me ghe schulen heere him. This it is that was in the chirche in wildirnesse with the aungel that spak to him in the mount Syna and with oure fadris, which took wordis of lyf to ghyue to us: to whom oure fadris wolden not obeie, but puttiden him awei, and weren turned awei in hertis into Egipte, seiynge to Aaron, Make thou to us goddis that schulen go bifore us; for to this Moises that ledde us out of the lond of Egipte, we wite not what is don to hym. And thei maden a calf in tho daies, and offriden a sacrifice to the mawmet, and thei weren glad in the werkis of her hondis; and God turnyde and bitook hem to serue to the knyghthood of heuene; as it is writen in the book of prophetis, Whether ghe hous of Israel offriden to me slayn sacrifices, either sacrifices of oostis fourti gheer in desert? And ghe han take the tabernacle of Moloch, and the sterre of ghoure god Renfam, figuris that ghe han maad to worschipe hem: and I schal translate ghou into Babiloyne. The tabernacle of witnessyng was with our fadris in desert, as God disposide to hem, and spak to Moises, that he schulde make it aftir the fourme that he saigh: which also oure fadris tooken with Ihesu, and broughten into the possessioun of hethene men, which God puttide awei fro the face of our fadris til into the daies of Dauid, that foond grace anentis God, and axide that he schulde fynde a tabernacle to God of Iacob. But Salamon bildide the hous to him. But the high God dwellith not in thingis maad bi hond, as he seith bi the prophete, Heuene is a seete to me, and the erthe is the stool of my feet; what hous schulen ghe bilde to me? seith the Lord; either what place is of my restyng? whethir myn hond made not alle these thingis?"[3]

Contemporary with Wycliffe was Geoffrey Chaucer, who is commonly regarded as the father of English poetry, and who closed his life in the year 1400. Dr Johnson has remarked that "he may, perhaps, with justice, be styled the first of our versifiers who wrote poetically."[4] He was a man of original genius, improved by a familiar acquaintance with writers in several languages. For the native poets who preceded him, he appears to have entertained but little respect: he sought for better models among the Latin, Italian, and French writers, and in all these languages he found works which he either translated or imitated. He possessed a lively fancy, and was a shrewd observer of life and manners. He improved the language, and refined the taste of his contemporaries. He taught them to write, if not with new harmony, at least with new terseness. The work by which he is best known are his Canterbury Tales; and in these he not only exhibits many characteristic delineations of manners, but likewise evinces a rich vein of native humour. They commence with the following verses, which we have selected on account of the elaborate analysis to which they have been subjected by Mr Tyrwhit.[5]

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[1] Peter Langtoft's Chronicle, as illustrated and improved by Robert of Brunne, vol. ii. p. 297.
[2] Vision of Peirs Plouhman, p. 80. Whitaker's edit. Lond. 1813, 4to.
[3] New Testament, translated by Wiclif, p. 196. Baber's edit. Lond. 1810, 4to.
[4] Johnson's Hist. of the English Language, prefixed to his Dictionary.
[5] Canterbury Tales of Chaucer, vol. iv. p. 106. Lond. 1775, 5 vols. 8vo.

Whanne that April with his shoures sote
The droughte of March hath pierced to the rote,
And bathed every veine in swiche licour,
Of whiche vertue engendred is the flour;
Whan Zephirus eke with his sote brethe
Enspired hath in every holt and hethe
The tendre croppes, and the yonge sonne
Hath in the Ram his halfe cours yronne,
And smale foules maken melodie,
That slepen alle night with open eye,
So priketh hem nature in hir corages;
Than longen folk to gon on pilgrimages,
And palmeres for to seken strange strondes,
To serve halwes couthe in sondry londes;
And specially, from every shires ende
Of Englelond, to Canterbury they wende,
The holy blisful martyr for to seke,
That hem hath holpen whan that they were seke.

In the English language, as it thus appeared in the fourteenth century, the Anglo-Saxon vocabulary was still predominant, but the words had been greatly curtailed in their inflexions. This plan of simplifying the structure of speech is to be traced in other instances, where a rude or a strange race is mingled with a people who have cultivated a more complex language, bearing little or no resemblance to their own. The most essential part of the vocabulary may be acquired without difficulty; but it is not so easy to become acquainted with the inflexions of nouns and verbs, or with some other niceties which belong to language in its more complicated form. Many French words had now been incorporated with the English language; but the compositions of this period began to be marked by an affectation of words derived immediately from the Latin. If Chaucer did not set the example, he at least followed it; and when he aims at a more ornamented style, his use of such phraseology is sufficiently copious. In this respect, he was however exceeded by some of his successors, particularly Hoccleve, Lydgate, and Hawes, who inherited no portion of his strength and originality. Being deficient in taste as well as genius, they devised a verbose and languid style, interspersed with many sonorous and polysyllabic terms, with terms "aureate and mellifluate," which did not assimilate with their native tongue. The same false taste was at length communicated to the Scotish poets. Dr Nott has remarked that Barbour had given his countrymen a fine example of the simple energetic style, which resembled Chaucer's best manner, and wanted little to make it the genuine language of poetry; and that other poets of the same nation, particularly James the First and Henryson, adhered to this model of a simple diction, and affected no other ornament than what the proper use of their language supplied.[1] But ultimately the false taste, which had infected the English poets, was communicated to their brethren of the north.

Gower and Lydgate, whose names are very frequently mentioned with that of Chaucer, are well known to the readers of early English poetry. Thomas Hoccleve, whom his editor supposes to have been born about the year 1370, makes a more inconsiderable figure in the literary annals of that age, but seems nevertheless to claim a passing notice. He was deficient in the essential qualifications of a poet; and, in the opinion of Mr Warton, "his chief merit seems to be, that his writings contributed to propagate and establish those improvements in our language which were now beginning to take place."

The greater part of the fifteenth century was highly unfavourable to the progress of literature in England. The repeated contests for the crown, and the civil wars which they occasioned, were attended with a great waste of human blood, and with that incertainty of possession, and those reverses of fortune, which leave the mind but little relish for such pursuits as are chiefly calculated to gratify the taste. Some individuals, Sir John Fortescue, and a few other writers, have left favourable specimens of prose composition; and they were succeeded by others, who made further improvements in style. Among these we must include Sir Thomas More, Archbishop Cranmer, Sir Thomas Elyot, and Roger Ascham. But from the death of Chaucer, more than a century elapsed before another writer, deserving the name of a poet, appeared in England. This writer was Henry Howard, earl of Surrey, son and heir apparent to the duke of Norfolk, whom however he did not survive. He was beheaded in 1547, in the thirtieth year of his age. Although thus cut off before the full maturity of intellectual vigour, he lived long enough to effect some very material improvements in English poetry. The versification of preceding poets was more properly rhythmical than metrical. Although some improvements had been introduced by Chaucer, he left the number of syllables too indefinite, and did not reach the harmony and compression, of which this noble poet afterwards exhibited an example. One of the changes which he introduced was the use of the heroic blank verse. Langland and other poets had indeed dispensed with rhyme; but their alliterative lines were constructed in a very different manner. In the following sonnet, he bewails the death of another eminent poet, Sir Thomas Wyatt.

Divers thy death do diversely bemoan:
Some, that in presence of thy livelihed
Lurked, whose breasts envy with hate had swoln,
Yield Cæsar's tears upon Pompeius' head.
Some that watched with the murd'rer's knife,
With eager thirst to drink thy guiltless blood,
Whose practice brake by happy end of life,
Weep envious tears to hear thy fame so good.
But I, that knew what harboured in that head,
What virtues rare were tempered in that breast,
Honour the place that such a jewel bred,
And kiss the ground whereas thy corpse doth rest,
With vapoured eyes, from whence such streams avail
As Pyramus did on Thisbe's breast bewail.

Before the close of the sixteenth century, the English language had in a great measure attained that form and structure which it continues to exhibit. A great improvement of taste had been introduced by a more critical and more general study of the ancient classics. William Lilly, the famous grammarian, who had learned Greek at Rhodes, and who had afterwards acquired a polished Latinity at Rome, became the first teacher of Greek at any public school in England. This was at St Paul's school in London, of which he was appointed the first master about the year 1500.[2] The language soon began to be more regularly taught in the universities. At Cambridge the study of it was zealously and successfully recommended by Smith, Cheke, and Ascham, who were themselves distinguished by their proficiency. The elegancies of Latin style began to be better understood, and monkish barbarism was gradually banished. Ascham and Haddon acquired distinction by the style of their Latin prose; and some of the verses of Leland discover a classical vein previously unknown to his countrymen. Before the close of the century, many of the Greek and Latin writers appeared in an English dress, and classical story, with classical mythology, was rendered familiar to the common reader. In addition to the French, the Italian and Spanish languages attracted a great degree of attention; and from all these languages, especially the two former, many works were likewise translated. New sources of knowledge, as well as of fancy, were thus opened, and the English tongue was enriched with a more copious and variegated phraseology. Surrey and Wyatt were succeeded by poets of great genius, by Shakspeare and Spenser, as well as by many others who, though of inferior powers, were yet possessed of a vigorous and brilliant imagination. The prose compositions of Bacon and Raleigh, partaking of the native energy of their authors, exhibited specimens of a condensed and forcible style, to which the preceding age had never attained. During the earlier part of the seventeenth century, ancient learning was assiduously cultivated; and men of great erudition, Selden, Gataker, and others, adorned the literary annals of their country. The prevailing taste of scholars had however a strong tendency to what was scholastic, if not pedantic; and even the poets, such as Donne and Cowley, substituted the subtilties of metaphysical conceits for flights of poetic fancy. Many words, derived immediately from the Latin, were introduced by the learned writers of the period to which we now refer. A considerable number of these has been subsequently rejected, while others are incorporated in the vocabulary. In the mean time, English poetry had nearly reached its highest limits. Milton's Paradise Lost, so eminently distinguished as a work of creative genius, affords the most remarkable illustration of the compass, power, and harmony of the language. Nor is Dryden unworthy of being mentioned with this mighty master of the English lyre. His powers of mind were no doubt different in kind and degree, but he was possessed of a genius truly poetical; and his prose, as well as his verse, exhibits a rich and copious vein of English phraseology.

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[1] Nott's Dissertation on the State of English Poetry before the Sixteenth Century (p. cxc.), prefixed to the Works of Surrey and Wyatt. Lond. 1815, 2 vols. 4to.

[2] Warton's Hist. of English Poetry, vol. iii. p. 258.

The subsequent progress of the language our narrow limits will not permit us to trace. The history of the Scotish language is involved in more obscurity. The Celtic tongue is supposed to have been originally spoken in every district of this kingdom; nor has it been found an easy task to account for the introduction of a Gothic dialect, bearing a very close affinity to English. That the Scotish language is merely a dialect of the English, seems indeed to be the more prevalent opinion; and this foreign speech is supposed to have been gradually adopted by the Picts, who are at the same time described as a people of Celtic origin. The ancient history of every race of men which is possessed of no ancient records, and which has not attracted much attention from more enlightened nations, must ever be involved in doubt and incertainty. In the present instance, we have little to guide our enquiries, besides a few scattered and contradictory notices, added to the ordinary and well-ascertained progress of human speech. When other records fail, the history of a nation may sometimes be traced in the history of its language; and a very moderate degree of reflection will enable us to determine the probability of a Celtic people thus unlearning their native tongue, and from deliberate choice adopting another speech completely and radically different.

Dr Geddes, in a Dissertation on the Scoto-Saxon Dialect, has strenuously maintained this extraordinary opinion, which has likewise been adopted by a more recent writer, possessing no portion of his acuteness or learning. "The names," it is stated, "of all the rivers, mountains, towns, villages, and castles, of any note or antiquity, from Berwick-law to Buchanness, and from Buchanness to Arder-Sier, are all evidently Celtic. We must then either suppose that the language of the Picts was a dialect of the Celtic; or that they were not the original inhabitants of the country; or, in fine, that, after the extinction of the Pictish empire, or rather its union with the Irish-Scots, the language of these latter universally prevailed, and effaced the very remembrance of its Gothic predecessor. The second of these suppositions is contrary to history; the third is belied by experience; the first then is the only one that is founded in probability."[1] This observation with respect to the prevalence of Celtic names, though too strongly stated, is not without foundation. We may therefore admit that the south of Scotland was at some remote period inhabited by a Celtic people; but it is not a necessary inference that this people must be identified with the Picts. Whatever hypothesis may be adopted, it is not denied that many Celtic names of places have been retained where the inhabitants have long ceased to speak any dialect of the Celtic language. It may very easily be conjectured that this primitive race of Celts was finally supplanted by new settlers: and that those settlers, whether Scandinavians or some other Gothic tribe, adopted many of the names which the original inhabitants had applied to mountains, rivers, and other conspicuous objects. That a similar process has been followed in innumerable instances, must be obvious to every person acquainted with the history of European settlements in other quarters of the globe: the native appellations are almost always retained to a certain extent, and are mingled with other names, borrowed from the language of the colonists.

If we should suppose the Picts to have been a Celtic people, a very hard problem will remain to be solved:—by what extraordinary means could a distinct race of men, placed in such circumstances, be induced to reject one language, and to adopt another? This radical and unprecedented change Dr Geddes is disposed to ascribe to the operation of such causes as the following; to the temporary subjection of the southern provinces of Scotland by the Northumbrians; to the immense number of captives seized during the ancient wars with the English; to the planting of English garrisons in several of the Scotish towns; to the amicable intercourse of the Picts with the English; and, finally, to the influence of Malcolm Canmore's courtiers, whom he supposes to have learned the English language from Queen Margaret and her retinue. But it may without temerity be affirmed that, in the entire annals of the human race, such an effect was never produced by such causes. In a more refined state of society, the love of knowledge, the hope of gain, or the influence of fashion, may induce many individuals to betake themselves to the acquisition of foreign languages; but the great body of the people will ever be disposed to rest perfectly satisfied with the speech, whether rude or cultivated, which they have derived from their parents. It is only by some great revolution, by a total conquest, or by an overwhelming extent of colonization, that the current language of a country can be materially changed. After the Norman conquest, when French became the language of the court and of the law, and when Norman barons were planted in almost every corner of England, did the combined operation of such causes eradicate the old, and establish a new language in its place? Many new words were unquestionably introduced, but these were merely engrafted on the old stock of the Anglo-Saxon. "Had the Saxon," as Dr Jamieson well observes, "found its way into Scotland in the manner supposed, it would necessarily have been superinduced on the Gaelic. This has always been the case, where one language prevailed over another; unless the people who spoke the original language were either completely or nearly exterminated. Thus was the Norman gradually incorporated with the Saxon, as the Frankish had been with the Latinized Celtic of France. But the number of Gaelic words to be found in what is called Broad Scots bears a very small proportion to the body of the language."[1] And this solitary fact is indeed sufficient to evince that the inhabitants of the south of Scotland cannot be sprung from Celtic ancestors. Dr Geddes has ventured to specify the reign of Malcolm the Third, which commenced in the year 1057, as the period of a general denization of the Saxon tongue in Scotland. "That monarch," he remarks, "had been bred in England, and married an English princess. Her retinue were all English. English, in consequence, would become the language of the court. The courtiers would carry it to their respective homes; their domestics would be ambitious to speak the language of their masters; and thus it would be gradually introduced into every fashionable circle."[2] But to introduce a language into every fashionable circle, is somewhat different from rendering it the current speech of the people: French has long been the court language, and the language of fashionable circles in England, and yet the great body of the people still persist in speaking English.

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[1] Transactions of the Society of the Antiquaries of Scotland, vol. i. p. 408.

The insuperable difficulty of accounting for such a transition as has thus been supposed, a transition from a Celtic to a Gothic dialect, renders the conclusion obvious and unavoidable, that the Gothic speech of Scotland was derived from a Gothic race of ancestors. Nor is this conclusion altogether free from difficulties, though they are of very inferior weight to those which are to be deposited in the opposite scale. It is the opinion of a late writer, who has investigated the subject with much ability, that the Picts emigrated from Scandinavia;[3] and, according to this opinion, the Picts and Saxons must have spoken two dialects of the same original tongue. The history of these kindred dialects may be illustrated from that of some others, derived from the same Gothic origin. The Islandic, Swedish, and Danish languages are all descended from the ancient Scandinavian. Island, which, as the learned Bishop Müller has remarked, is entitled to particular attention as the foster-mother of northern history,[4] was peopled by a colony of Norwegians in the year 874. This race of men, confined to a remote island, and maintaining but little intercourse, either of peace or war, with other nations, has preserved its ancient language with singular purity.[5] The Swedes and Danes, more extensively engaged in the pursuits of commerce, and more closely connected with the rest of mankind, have exhibited a different progress: but while both languages have receded very widely from the Islandic, they have not receded very widely from each other; a similar state of society, similar relations with other countries, and the study of the same foreign authors, have produced corresponding changes in both. In the history of these two languages, we do not find a complete parallel with that of the Scotish and English: the Swedish and Danish are both dialects of the ancient Scandinavian, while the Scotish is derived from the Scandinavian, and the English from the ancient German. But the Scandinavian and the German proceeded from the same common stock; and when we ascend to a period sufficiently remote, they are only to be regarded as dialects of the same language.

It is not to be concealed that Barbour, Winton, Henry the Minstrel, and other early poets of Scotland, have described their native language as English.[6] This application of the name has been explained, with at least some degree of plausibility, by referring to the circumstance of the Gaelic being then denominated the Scotish language.[7] A Celtic and a Gothic dialect could not well be described by the same term; and "when, by a necessary contingency, the Gothic language had in the same space, though in different nations, retained much the same hues, the name of that dialect, which was spoken by the greater and politer people, was imparted to the other, inhabiting a contiguous part of the very same island."[8] Mr Pinkerton is less fortunate in another suggestion; namely, that it is not more strange to perceive that the Italian, French, and Spanish languages were originally termed Romance. They were all described by this common name, because they were all derived from the language of the Romans; but we are not inclined to believe that the Scotish and the English tongues stand in precisely the same relation to each other. (x.)

ENGRAFTING, in *Gardening*. See HORTICULTURE.

ENGRAILED, or INGRAILED, in *Heraldry*, a term derived from the French *gresle*, hail; and signifying a thing the hail has fallen upon and broken off the edges, leaving them ragged, or with half rounds, or semicircles, struck out of their edges.

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[1] Jamieson's Dissertation on the Origin of the Scottish Language (p. 21), prefixed to his Dictionary.

[2] Verstegan reasons in nearly the same manner. (Restitvtion of decayed Intelligence, p. 180. Antwerp, 1605, 4to.) See likewise the preface to Dr Wallis's Grammatica Linguæ Anglicanæ, p. xxii. and Mr Boucher's Introduction to his Glossary of Obsolete and Provincial Words, p. li.

[3] Pinkerton's Enquiry into the History of Scotland, vol. i. p. 168. Lond. 1789, 2 vols. 8vo.—Mr Roberts inclines to the same opinion: "The Picts, or more properly Phichts, probably a colony of Scandinavians, originally from Scythia, as they are said to have come over the northern sea. Triad 7." (Sketch of the Early History of the Cymry, or Ancient Britons, p. 125. Lond. 1803, 8vo.) Professor Magnusen, who has more recently investigated the origin of the Picts, bestows sufficient commendation on Mr Pinkerton's learning and research, and to a certain extent is disposed to adopt his leading opinion; but at the same time he declares himself unable to approve of all the arguments by which it is supported, especially of those which rest upon erroneous interpretations of Scandinavian words and antiquities; nor does he fail to express his disapprobation of this writer's unseasonable invectives against the Celts. (Om Picternes og deres Navns Oprindelse, S. 56. Kiöbenhavn, 1817, 8vo.)

[4] Müller's Sagabibliothek, Bind i. S. 4. Kiöbenhavn, 1817–20, 3 Bind. 8vo.

[5] Dr Sharpe has well stated that "war, invasion, conquest, treaties, intercourse with different nations, commerce, colonies, rise of arts, logical refinements, controversies, time or age, and the humours of a people, are all causes of alteration in language." (Two Dissertations, upon the Origin of Languages, and upon the original Powers of Letters, p. 35. edit. Lond. 1751, 8vo.)

[6] Barbour's Bruce, p. 82. Winton's Cronykil, vol. i. p. 4. Henry's Wallace, p. 231.

[7] "Duobus enim utuntur linguis, Scotica videlicet, et Teutonica, cujus linguæ gens maritimas possidet et planas regiones: linguæ vero gens Scoticæ montanas inhabitat, et insulas ulteriores." (Forduni Scotichronicon, vol. i. p. 44. edit. Goodall.)

[8] Pinkerton's Essay on the Origin of Scotish Poetry (p. lxxi.), prefixed to Ancient Scotish Poems. Lond. 1786, 2 vols. 8vo.

ENGRAVING.

Engraving is the art of cutting metals and precious stones, and representing thereon figures, letters, or whatever device or design the artist chuses.

Engraving being properly a branch of sculpture, is divided into several other branches, according to the matter on which it is employed, and the manner in which it is performed. For the method of

Engraving *on Wood*, see Wood, *Engraving on.*

Engraving on Copper is the making, conformably to some delineated figure or design, such concave lines on a smooth surface of copper, either by cutting or corrosion, as render it capable, when charged properly with any coloured fluid, of imparting by compression, to paper or any similar substance, an exact representation of the figure or design.

Whether we consider the art of engraving, with regard to the utility and pleasure it affords, or the difficulty which attends its execution, we cannot but confess, that on every account it deserves a distinguished rank amongst the polite arts. It is by means of this art that the cabinets of the curious are adorned with the portraits of the greatest men of all ages and all nations. It is by this art also that the paintings of the greatest masters are multiplied, and that the lovers of the polite arts are enabled to enjoy those beauties from which their distant situations seemed to have for ever debarred them; and persons of moderate fortune are thereby enabled to become possessed of all the spirit, and all the poetry, contained in those miracles of art, which seemed to have been reserved for the temples of Italy or the cabinets of princes. When we reflect, moreover, that the engraver, besides the beauties of poetical composition, and the artful ordinance of design, has to express, merely by the means of light and shade, all the various tints of colour and clear obscure,—to give a relief to each figure, and a truth to each object; that he has now to represent a sky serene and bright, and then one loaded with dark clouds,—now the pure tranquil stream, and then the foaming sea tempest-driven; that here he has to express the character of the man, strongly marked in his countenance, and there the minutest ornament of his dress; in a word, that he has to represent all, even the most difficult objects in nature;—we cannot sufficiently admire the vast improvements in this art, and that degree of perfection to which it has at this day arrived. See the article Prints.

Engraving is an art which for the most part is of modern invention, having taken its rise no earlier than the middle of the fourteenth or fifteenth century. The ancients, it is true, practised engraving on precious stones and crystals with very good success; and there are still many of their works remaining, equal to any production of later times. But the art of engraving on plates and blocks of wood, in order to afford prints or impressions, was not known till after the invention of painting in oil.

The different modes of engraving are the following:

1. In strokes cut through a thin wax, called etching ground, laid upon the copper, with a point, and these strokes bitten or corroded into the copper with aquafortis. This is called *etching.*

2. In strokes with the graver alone, unassisted by aquafortis. In this instance, the design is traced with a sharp tool, called a *dry point*, upon the plate; and the strokes are cut or ploughed upon the copper with an instrument of an angular form, distinguished by the name of a *graver.*

3. In strokes first etched and afterwards finished with the graver. By this expedient the two former methods are united.

4. In dots without strokes, which are executed with the point upon the wax or etching ground, bitten in with the aquafortis, and afterwards harmonized with the graver, by means of which instrument small dots are made, or with the graver alone, as in the flesh and finer parts, unassisted with the point.

5. In dots first etched and afterwards harmonized with the dry point, performed by a little hammer; called *opus mallei*, or *the work of the hammer*, as practised by Lutma and others.

6. In mezzotinto, which is performed by a dark barb or ground being raised uniformly upon the plate by means of a toothed tool. The design being traced upon the plate, the light parts are scraped off by instruments for that purpose, in proportion as the effect requires.

7. In aquatinta, a newly-invented method of engraving, in which the outline is first etched, and afterwards a sort of wash laid by the aquafortis upon the plate, resembling drawings in Indian ink, bister, &c. See Aquatinta.

8. On wood, consisting of a single block, on which the design is traced with a pen, and those parts which should be white carefully hollowed out. This block is afterwards printed by the letter-press printers, in the same manner as a book is printed.

9. On wood, consisting of two, three, or more blocks, the first having the outlines cut upon it, the second being reserved for the darker shadows, and the third for the shadows which terminate upon the lights; and these are substituted in their turn, each print receiving an impression from every block. This mode of engraving is called *chiaro-scuro*, and was designed to represent the drawings of the old masters.

10. On wood and on copper. In these the outline is engraved in a bold dark style upon the copper; and two or more blocks of wood are substituted to produce the darker and lighter shadows as before.

Of all those modes of engraving, the most ancient is that on *wood;* or, to speak more properly, the first impressions on paper were taken from carved wooden blocks. From this invention it appears that we are indebted to the brief-malers, or makers of playing-cards, who practised the art in Germany about the beginning of the fifteenth century. From the same source may perhaps be traced the first idea of moveable types, which appeared not many years afterwards; for these brief-malers did not entirely confine themselves to the printing and painting of cards, but produced also subjects of a more devout nature, many of which, taken from holy writ, are still preserved in different libraries in Germany, with the explanatory text facing the figures, and the whole engraved in wood. In this manner they even formed a species of books; such as *Historia sancti Johannis, ejusque Visionis Apocalypticæ*, and *Historia Veteris et Novi Testamenti*, known by the name of *Poor Man's Bible.* These short mementos were printed only on one side; and two of them being pasted together, had the appearance of a single leaf. The earliest date on any of these wooden cuts is 1423, and the subject is *St Christopher carrying the Infant Jesus over the Sea*, preserved in a convent at Buxheim near Menningen. It is of a folio size, illuminated in the same manner as the playing cards; and at the bottom is the inscription, *Christoferi faciem die quacunque tueris. Illa nempe die morte mala non morieris. Millesimo CCCC° XX° tertio.*

Upon the invention of moveable types, that branch of the brief-maler's business, as far as it regarded the making of books, was gradually discontinued; but the art itself of engraving on wood continued in an improving state; and towards the end of the fifteenth and the beginning of the sixteenth century, it became customary for almost every one of the German engravers on copper to engrave on wood also, as may be seen from the first printed books, in which the initial letters were for the most part highly ornamented with various appropriate devices. The works of Albert Durer in this style of engraving are justly held in the highest esteem. Italy, France, and Holland have produced many capital artists of this description; but, for boldness and spirit, the palm must be given to the prints of Christopher Jegher, who worked under the direction of Rubens, and was without doubt assisted by that great master.

The invention of that species of engraving which is distinguished by the appellation of *chiaro-scuro* is also claimed by the Germans, and seems to have been first practised by Mair, one of whose prints of this kind is dated 1499. Many excellent works in chiaro-scuro have also been produced in France; and in Italy it was honoured with the performances of Titian and Parmegiano; but the attempts of Jackson, Kirkall, and others in England, have not been equally successful. Since these times, which may be called the infancy of wood engraving, the art has been carried to very great perfection in Britain; and the present day may boast of higher attainments in this branch than were reached at any former period.

In Germany, about the year 1450, prints from engraved *copper* first made their appearance. The earliest date of a copperplate print indeed is only the year 1461; but however faulty this print may be with respect to the drawing, and however defective in point of taste, the mechanical part of the execution has by no means the appearance of being one of the first productions of the graver. We have also several other engravings, evidently the work of the same master, in which the impressions are so neatly taken from the plates, and the engravings so clearly printed in every part, that according to all appearance they could not be executed in a much better manner at the present day, with all the conveniences which the copperplate printers now possess, and the additional knowledge they must necessarily have acquired in the course of more than three centuries. Hence we may fairly conclude, that if these were not the first specimens of the engraver's workmanship, much less were they the first efforts of the copperplate printer's ability. It is likewise to be observed, that Martin Schoen, who is said, with great appearance of truth, to have worked from 1460 to 1486, was apparently the scholar of Stoltzhirs; for he followed the style of the latter in engraving, and copied from him a set of prints representing the passion of our Saviour. Now, allowing Stoltzhirs to have preceded his disciple only ten years, this carries the era of the art back to 1450, as was stated above. But there is no ground to suppose that it was known to the Italians till at least ten years afterwards. The earliest prints which are known to be theirs are a set of the seven planets, and an almanack by way of frontispiece, on which are directions for finding Easter from the year 1465 to 1517 inclusive; and we may be well assured that the engravings were not antedated, for the almanack of course became less and less valuable every year. In all probability, therefore, these prints must have been executed in the year 1464, which is only four years later than the Italians themselves lay any claim to. The three earliest Italian engravers are, Finiguerra, Boticelli, and Baldini. But if we were to refer these prints to any of the three, we should naturally conclude them to be the work of Finiguerra or Baldini; for they are not equal either in drawing or composition to those ascribed to Boticelli, which we know at least were designed by that artist; and as Baldini is expressly said to have worked from the designs of Boticelli, it appears most probable that they belong to Finiguerra.

With respect to the invention of *etching*, it is not well known to whom it ought to be ascribed. One of the earliest specimens is the print by Albert Durer, known by the name of the *Canon*, dated 1518, and thought by some, with little foundation, to have been worked on a plate of iron. Another etching by the same artist is Moses receiving the Tables of the Law, dated 1524. Etching was also practised in Italy soon after this by Parmegiano, in whose productions we discover the hand of the artist working out a system as it were from his own imagination, and striving to produce the forms which he wanted to express. We see the difficulty he laboured under; and, from the examination of the mechanical part of the execution of his works, we cannot doubt that he had no instruction, and that it was something entirely new to him. If the story be true that he kept an engraver by profession in his house, the novelty of the art is rendered so much the more probable. He died in 1540.

The art of engraving by corrosion, or what is called etching, with aquafortis, must have very early suggested itself to the discoverers of copperplate printing; for it seems to have been the method used by the manufacturers of warlike implements in their decorations of sword-blades and the like: and thus the same artists would soon perceive the facilities afforded by a mode at once easy and expeditious when applied to higher branches, such as the copies of pictures and works of art in general.

As to that species of engraving in which the modes of *etching* and *cutting* with the graver are united, it must have been found necessary immediately upon the invention of etching: it was, however, first carried to perfection by Audran, and is now almost universally practised, whether the work is in strokes or in dots.

Engraving in *dots* is a very old invention, and attributable to the Italians. Agostina de Musis, commonly called *Augustin of Venice*, a pupil of Marco Antonio, used it in several of his earliest works, but confined it to the flesh, as in the undated print of An Old Man seated upon a Bank, with a cottage in the background. He flourished from 1509 to 1536. We also find an example of this method in a print of "A single figure standing, holding a cup and looking upwards," by Giulio Campagnola, who engraved about the year 1516. The background is executed with round dots, made apparently with a dry point; the figure is outlined with a stroke deeply engraved, and finished with dots, in a manner greatly resembling those prints which Demarteau engraved at Paris in imitation of red chalk; and the hair and beard are expressed by strokes. Stephen de Laulne, a native of Germany, followed the steps of Campagnola; and many of his slight works are executed in dots only. Jean Boulanger, a French artist, who flourished in the middle of the last century, and his contemporary Nicholas van Plattenberg, improved greatly on this method, and practised it with much success. It is only, however, of late that it has been considered as an object worthy of general imitation. John Lutma executed this kind of work with a hammer and a small punch or chisel.

The method of engraving in *mezzotinto* was invented about the middle of the seventeenth century; and the invention has generally been attributed to Prince Rupert. See Mezzotinto.

Of the method of engraving in aquatinta an account has already been given under that word. (See Aquatinta.)

But it appears to us not out of place to give the following general directions; and for more particular information the article already mentioned may be consulted.

Engraving in aquatinta was originally invented by Le Prince, a French artist. For a long time, however, his process was kept secret; and his prints, it is said, were at first sold for drawings. As a proof that the art rose at once to perfection, as has already been mentioned, the prints which were executed by him are still admitted to be the finest and best specimens of the art. It appears, however, that he was only acquainted with the powdered grain, and the common method of stopping out. The first who practised this art in England was Mr Paul Sandby. By him, we are informed, it was communicated to Mr Jukes, whose works afford excellent examples of the perfection to which the art has been carried; and although it is now generally practised all over Europe, yet in no country is this done with greater success than in Britain.

The principle of this process consists in corroding the copper in such a manner that an impression from it exhibits the appearance of a tint laid on paper, or a drawing in Indian ink. This is accomplished by covering the copper with some substance which assumes a granulated form, and prevents the acid from acting where the particles adhere; and thus the copper is only partially corroded. The more minute the particles are, it is obvious the impression from the plate will more nearly resemble a wash of Indian ink, or a drawing; but the larger the particles are, the granulation becomes more distinct. The powder or granulation is called the *aquatinta grain*, and is produced in two ways.

The process for using the powdered grain, which was first employed, is the following. The outline being etched on a copper-plate, some substance, which easily melts with heat, adheres to the plate when cold, and resists the action of the aquafortis, is to be finely powdered and sifted. Besides asphaltum, rosin, and gum sandaric, the substances which have been mentioned in the article already referred to, Burgundy pitch, gum copal, gum mastic, as well as some other resins and gum resins, may be employed. Gum copal, it is observed, produces a grain which resists the aquafortis extremely well. Whatever the substance be which is to be employed, the great object of the artist in its application is, to have it equally distributed over the plate. This is an essential part of the operation, and requires considerable attention. The usual method is to tie up a quantity of the powder in a piece of muslin, and to strike it against a stick held at a considerable height above the plate. Thus managed, the powder settles equally over it. The plate being thus covered equally with the dust or powder, the latter is to be fixed upon it by the application of a gentle heat, to melt the particles. This is usually done by holding lighted pieces of paper rolled up, and moving them about till the whole of the powder is melted, which is known by its changing to a brown colour. It is now allowed to cool, and after being examined with a magnifying glass, if the particles appear to be uniformly distributed, the artist proceeds to the next part of the process.

Those parts of the design or drawing to be engraved, which are perfectly white, are to be observed and marked, and the corresponding parts of the plate must be covered or stopped out. This is best done by means of mastic varnish, diluted to such a consistence with turpentine as to work freely with the hair pencil. To give it colour, lampblack should be mixed with it, in order that the touches of the pencil may be distinctly seen. When those parts of the plate which are stopped out are sufficiently dry, a border of wax is raised round the plate, in the same manner as in etching, and the aquafortis, diluted with water, is poured on. This, being the most precarious part of the process, requires the greatest experience. When it is supposed that the aquafortis has remained on the plate for such a length of time that when the impression is taken it will produce the lightest shade in the drawing, it is poured off, and the plate is washed with water and dried. The lightest tints are then stopped out, and the aquafortis is again poured on; and this process is repeated as often as there are tints or shades to be produced in the plate.

Many plates are entirely etched in this way, by alternately stopping out and biting in. It is, however, found to be extremely difficult, and indeed impossible, to produce impressions of minute and complicated objects with the requisite degree of delicacy and freedom. To obviate this difficulty another process has been proposed, by which the touches are laid on the plate with equal ease and expedition as on drawings made with Indian ink. Fine washed whitening is mixed with treacle or sugar, and diluted with water in the pencil, that it may work freely. This is laid on the plate covered with the aquatint ground, in the same way as ink upon the drawing. When this is dry, the whole of the plate is varnished over with a thin turpentine or mastic varnish, and when this is dry the aquafortis is poured on. The varnish immediately breaks up in those parts of the plate where the treacle mixture was laid, and thus they are exposed to the action of the acid, whilst the other parts of the plate remain untouched. Thus the touches or places of the plate where the treacle has been applied are bit in deeper than the rest, and have the precision of touches done with Indian ink. The plate being thus completely bit in, the bordering wax is removed, by gently heating it with a piece of lighted paper. It is then cleared from the ground and varnish by means of oil of turpentine; and being wiped clean with a rag, it is ready for the printer.

But in this method of aquatinting it is found difficult to produce the necessary degree of coarseness or fineness in the grain; and plates which are engraved in this manner afford but a small number of impressions before they are worn out. On this account it is now more rarely followed.

The other method of producing the aquatint ground, which is most generally adopted, is the following. A resinous substance, as common resin, Burgundy pitch, or mastic, is dissolved in spirits of wine. This solution is poured all over the plate, which is inclined, till the whole of the superfluous fluid is drained off, and what adheres to the plate becomes quite dry in a few minutes. The plate being then examined with a magnifying glass, it will appear that the whole of the spirit having evaporated, the resinous matter is left in a granulated state, or is cracked in every direction, and adheres strongly to the copper. In this way a regular and beautiful grain is easily produced, which will be found preferable, at least for most purposes, to that which is produced by the former method. The grain being thus formed, the other parts of the process are conducted in the same manner as before described.

Such are the usual methods of conducting this process. We shall add a few hints which may be found useful respecting the different parts of it. With regard to the materials which are employed, it is to be observed that the spirits of wine should be rectified, and of the very best quality. Resinous matters, as common resin, Burgundy pitch, and gum mastic, yield grains of a different appearance and form; so that advantage may be taken of this circumstance by using them sometimes separately, and sometimes mixed in different proportions, according to the views and taste of the artist. Different proportions of resin may be employed to produce grains of different kinds. When a coarse grain is intended, a greater proportion is to be employed; and when a fine grain is wanted, a smaller proportion of resin only is required. The proper proportions may be ascertained by providing a number of spare pieces of copper; on these the liquid may be poured, and the grain examined, before it is applied to the plate which is to be engraved. After the solution is made, it should remain undisturbed for a day or two, till the impurities of the resin have subsided, and the liquid becomes quite limpid. This is the best method of freeing it from impurities; for if it be strained through linen or muslin, it is mixed with hairs, which are extremely injurious to the grain. It may be added, that the apartment in which the fluid is poured on the plate should be perfectly still, and entirely free from dust; for if any fall on the plate while it is wet, the grain forms a white spot, which cannot be removed. Great care should be observed in cleaning the plate before the ground is laid on. This is done with a bit of rag and whitening. The smallest stain or particle of grease produces a streak or blemish in the grain. Still, however, with all the attention which can be employed, and with the utmost delicacy in the management, it is necessary to observe that the process is extremely precarious and uncertain; and even the most experienced artists find themselves frequently subject to very unaccountable accidents.

Artists have frequently complained of the inconvenience arising from the fumes which proceed from the action of the acid upon the copper when the plate is large. To remedy this inconvenience, the following arrangement, which seems well calculated to answer the purpose, was suggested by Mr Cornelius Varley, an artist who distinguished himself no less by his mechanical abilities than by the exquisite productions of his pencil in water colours: "Get a frame made of common deal, or any kind of wood, three or four inches deep, covered with a plate of glass, and open at one side; and let the side opposite to this have a round opening, communicating by means of a common iron pipe with the ash-pit of any little stove or other fire-place, shut up from all other access of air but what must pass through the pipe. It is obvious that any fumes rising from a copper-plate laid under such a frame will be carried backward into the iron pipe by the current of air required to maintain combustion in the stove, and will by this means be carried up the chimney, in place of being allowed to fly about in the apartment. The pipe may be very conveniently used by carrying it down through the table to the floor, and so along to the place where the chimney may chance to stand; and when the frame is not wanted, the pipe at one of the joinings may be made to answer the purpose of a hinge, by which to turn up the frame against the wall, where it may be secured, while out of use, by a button or any other contrivance."[1]

This method of engraving in aquatinta seems to be chiefly adapted for slight subjects in general, and for imitations of sketches and washed drawings. But for the production of prints from finished pictures it is by no means calculated, because it is not susceptible of that accuracy in the nice management of the tints which is necessary for this purpose. It is equally unsuitable for book plates, because, without retouching the plates, the number of impressions which can be thrown off is very small. On these accounts, therefore, it is to be considered as greatly inferior to the other modes of engraving. But as it is more expeditious, and may be attained with greater facility, it is undoubtedly useful when it is confined to those subjects for which it is peculiarly calculated. This rapidity of execution, however, and facility in acquiring the practice of the art, are followed with the unfortunate circumstance, that they favour the production of an indiscriminate multitude of prints, which, it is to be feared, may rather tend to vitiate than improve the public taste.

Engraving with the tool was the kind originally practised, and it is yet retained for many purposes. For though the manœuvre of etching be more easy, and other advantages attend it, yet where great regularity and exactness of the stroke or lines are required, the working with the graver is much more effectual; on which account it is more suitable to the precision necessary in the execution of portraits, as there every thing the most minute must be made out and expressed, according to the original subject, without any license to the fancy of the designer in deviating from it, or varying the effect either by that masterly negligence and simplicity in some parts, or those bold sallies of the imagination and hand in others, which give spirit and force to history painting.

The principal instruments used in engraving with the tool are, gravers, scrapers, a burnisher, an oil-stone, and a cushion for bearing the plates.

Gravers are made in several forms with respect to the points, some being square, others lozenge; the square graver being designed for cutting broad and deep, and the lozenge for more delicate and fine strokes and hatches. The most generally useful are those of a form between the square and lozenge; and they should be of a good length, small towards the point, but stronger upwards, that they may have strength enough to bear any stress which there may be occasion to lay upon them; for if they be too small and mounted high, they will bend, which frequently causes their breaking, especially if they be not employed for very small subjects.

The burnisher is used to assist in the engraving on some occasions, as well as to polish the plates. It is made of fine steel well polished. The burnisher is sometimes formed at one end, and a scraper on the other, each about an inch and a half long from the point; between them about four inches of the instrument is made round, and serves as a handle, and is thicker in the middle than at the necks, where the burnisher and scraper begin, which necks are only a quarter of an inch in diameter. The principal application of the burnisher in engraving, besides its use in polishing the plates, is to tone and harmonise the work, and to take out any scratches or accidental defacings that may happen to the plates during the engraving; or to lessen the effect of any parts that may be too strongly marked in the work, and require to be taken down.

A cushion, as it is called, is likewise sometimes used for supporting the plate in such a manner that it may be turned every way with ease. It is a bag of leather filled with sand, and should be of the size which will best suit the plates it is intended to bear. Cushions are round, and about nine inches over, and three inches in thickness.

The cushion, made as above directed, being laid on the table, the plate must be put upon it; and the graver being held in the hand in a proper manner, the point must be applied to the plate, and moved in the proper direction for producing the figures of the lines intended; observing, in forming lines, to hold the plate steady on the cushion, and where they are to be finer, to press more lightly, using greater force where they are to be broader and deeper. In making circular or other curve lines, hold your hand and graver steadily; and as you work, turn your plate upon the cushion against your graver, otherwise it will be impossible for you to make any circular or curved line with that neatness and command of hand which by this means may be acquired. After part of the work is engraved, it is necessary to scrape it with the scraper or graver, passed in the most level direction over the plate, to take off the barb or roughness formed by the cutting of the graver; but great care must be taken not to incline the edge of the scraper or tool in such a manner that it may take the least hold of the copper, as it would otherwise produce scratches in the engraving; and, that the engraved work may be rendered more visible, it may afterwards be rubbed over with a roll of felt dipped in oil. In using the graver it is necessary to carry it as level as possible with the surface of the plate; for otherwise, if the fingers slip betwixt them, the line that will be produced, whether curved or straight, will become deeper and deeper in the progress of its formation, which entirely prevents strokes being made at one cut that will be fine at their extremities and larger in the middle, and occasions the necessity of retouching, to bring them to that state. For this reason it is very necessary for those who would learn to engrave in perfection, to endeavour, by frequent trials, to acquire the habit of making such strokes, both straight and curved, by lightening or sinking the graver with the hand, according to the particular occasion. If, after finishing the design, any scratches appear, or any part of the engraving be falsely executed, such scratches or faulty parts must be taken out by the burnisher, and further polished, if necessary, by the above-mentioned roll.

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[1] *Philosophical Magazine*, vol. xxiii. p. 137.

The dry point, or needle, which has been of late much used in engraving, is a tool like an etching point, which being drawn hard on the copper, cuts a stroke and raises a burr; the burr is scraped off, and there remains a stroke more soft and delicate than can be produced in any other way.

Although the instruments for the use of the engraver above enumerated and described are very simple, yet we have thought it advisable to subjoin the following figures illustrative of their forms, and about half the dimensions of those employed.

Fig. 1.
Graver.

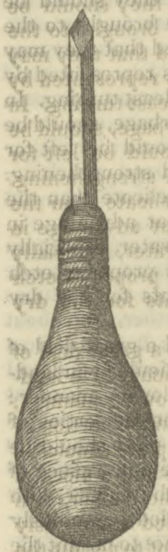


Fig. 2.
Dry Point, or Etching Needle.

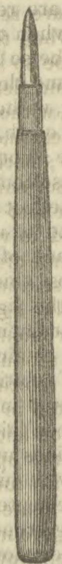


Fig. 3.
Scraper.

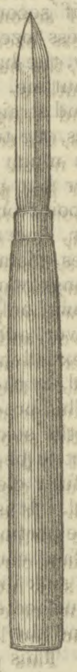


Fig. 4.
Burnisher.

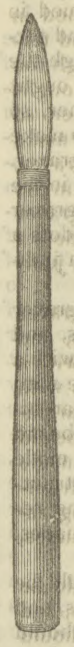


Fig. 5.
Ball of Etching Ground, covered with silk.

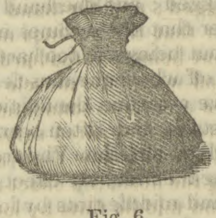
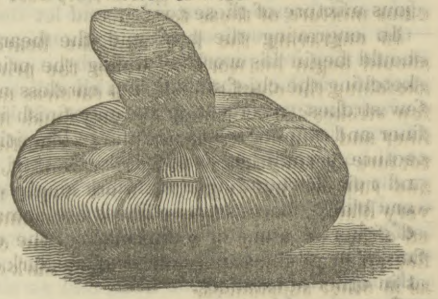


Fig. 6.
Dabber, covered with silk, and stuffed with cotton or wool.



The plate is covered with etching ground in the following manner: Heat it upon a stove or otherwise till it melt the ground in the silk bag, fig. 5, which must be spread equally over the surface of the copper by means of the dabber, fig. 6. The ground is then to be moderately smoked all over with a candle, and when the plate is cold it is ready for use.

Etching ground is composed of virgin wax and asphaltum each two ounces, and of black and Burgundy pitch each half an ounce. Melt the wax and pitch in a new-glazed earthen pot, and add to them by degrees the asphaltum finely powdered; boil the whole until such time as, by taking a drop upon a plate, it will break when it is cold, on bending it double three or four times between the fingers. The ground, being sufficiently boiled, must be taken off the fire, and, being allowed to cool a little, must be poured into warm water if the weather be cold, or cold water if the contrary, in order that it may be the more easily worked with the hands; for it should be pulled a long time, to mix the ingredients more completely, when it may be divided into small balls for use. The fire must be moderate, for fear of burning the ground; and the ingredients must be stirred during the whole time of preparation, particularly when the asphaltum is being put in.

Wax for surrounding the plate in the process of biting in with aquafortis is made of one pound of Burgundy pitch or black pitch, and of bees' wax half a pound, melted over a slow fire. When melted, add about a gill of sweet oil, and when moderately hot, pour the whole into water, pull it well, and fashion it into balls for use.

In the conduct of the graver and dry point consists the whole art, for which there are no rules to be given, all depending on the habitude, disposition, and genius of the artist. However, besides the explanations already given, some general observations and directions may not be improper. As the principles of engraving are the same with those of painting, a person cannot expect to attain any considerable degree of perfection in this art who is not a good master of design; and therefore he ought to be well acquainted with both perspective and drawing in general; for, by the proper degradations of strong and faint colours, he will be enabled to throw backwards the figures and other objects of the picture or design which he proposes to imitate, and which the painter often intrusts to the discretion of the engraver. In working, the strokes of the graver should never be crossed too much in a lozenge manner, particularly in the representation of flesh, because sharp angles produce the unpleasing effect of lattice-work, and take from the eye the repose which is agreeable to it in all kinds of picturesque designs; we should except the case of clouds, tempests, waves of the sea, the skins of hairy animals, or the leaves of trees, where this method of crossing may be admitted. But in avoiding the lozenge, it is not proper to get entirely into the square, which would give the work too much of the hardness of stone. In conducting the strokes, the action of the figures and of all their parts should be considered; it should be observed how they advance towards or recede from the eye; and the graver should be guided according to the risings or cavities of the muscles or folds, making the strokes wider and fainter in the light, and closer and firmer in the shades. Thus the figures will not appear jagged; and the hand should be lightened in such a manner that the outlines may be formed and terminated without being cut too hard. However, though the strokes break off where the muscle begins, yet they ought always to have a certain connection with each other, so that the first stroke may often serve by its return to make the second, which will show the freedom of the engraver.

In engraving the flesh, the effect may be produced in the lighter parts and middle tints by long peeks of the graver rather than by light lines, or by round dots, or by dots a little lengthened by the graver, or, best of all, by a judicious mixture of these together.

In engraving the hair and the beard, the engraver should begin his work by laying the principal lines, and sketching the chief shades, in a careless manner, or with a few strokes; after which he may finish it at leisure with finer and thinner strokes to the extremities. When architecture or sculpture is to be represented, except it be old and ruinous buildings, the work ought not to be made very black; because, as edifices are commonly constructed either of stone or white marble, the colour, being reflected on all sides, does not produce dark or brown shades, as in other substances.

In engraving cloths of different kinds, linen should be done with finer and closer lines than any other sorts, and be executed with single strokes. Woollen cloth should be engraved wide, in proportion to the coarseness or fineness of the stuff, and with only two strokes; and when the strokes are crossed, the second should be smaller than the first, and the third than the second. Shining stuffs, which are generally of silk or satin, and which produce flat or broken folds, should be engraved more hard and more straight than others, with one or two strokes, as their colours are bright or brown; and between the first strokes other smaller ones may be interlined. Velvet and plush are expressed in the same manner, and should always be interlined. Metals, as armour, &c. are also represented by interlining, or by clear single strokes. In architecture the strokes which form the rounding object should tend to the point of sight; and when whole columns occur, it is proper to produce the effect as much as possible by perpendicular strokes. If a cross stroke is put, it should be at right angles, and wider and thinner than the first stroke. In engraving mountains, the strokes ought to be frequently discontinued and broken for sharp and craggy objects; they should be straight, in the lozenge manner, and accompanied with long points or dots; and rocks should be represented by cross strokes more square and even. Objects which are distant towards the horizon should be kept very tender. Waters that are calm and still are best represented by strokes which are straight and parallel to the horizon, interlined with those that are finer, omitting such places as, in consequence of gleams of light, exhibit the shining appearance of water; and the form of objects reflected from the water at a small distance upon it, or upon the banks of the water, are expressed by the same strokes, retouched more strongly or faintly as occasion may require, and even by some that are perpendicular. For agitated waters, as the waves of the sea, the first strokes should follow the figure of the waves, and may be interlined, and the cross strokes, if any, ought to be very lozenge. In cascades the strokes should follow the fall, and may be interlined. In engraving clouds, the lines should sport, when they appear thick and agitated, in turning every way, according to their form and agitation. If the clouds are dark, so that two strokes are necessary, they should be crossed more lozenge than the figures, and the second strokes should be rather wider than the first. The flat clouds which are lost insensibly in the clear sky should be made by strokes parallel to the horizon, and a little waving; if second strokes are required, they should be more or less lozenge; and when they are brought to the extremity, the hand should be so lightened that they may form no outline. The flat and clear sky is represented by parallel and straight strokes, without the least turning. In landscapes, the trees, rocks, earth, and herbage, should be etched as much as possible; nothing should be left for the graver but perfecting, softening, and strengthening. The dry point produces an effect more delicate than the graver can, and may be used to very great advantage in linen, skies, distances, ice, and often in water, especially in small engravings. In most things it is proper to etch the shadows, only leaving the lighter tints for the dry point, graver, and other instruments.

Much excellence may be attained, and a great deal of time saved, by the process of rebiting, particularly in landscape. This process is effected in the following manner: When all the strokes have been laid in upon the portion of any subject to be rebit, the lines upon the plate should be very carefully cleaned out with turpentine and a piece of stale bread. It is then to be heated, and the dabber, with a moderate portion of etching ground, applied dexterously to the surface, care being taken, however, not to permit the ground to sink into the lines, but only to cover the intermediate surface effectually. The aquafortis is now to be applied, and the lines bit down or corroded to the depth required. This process is, comparatively speaking, of recent invention, and was wont to be esteemed precarious and difficult in the management; but a little experience, and the great demand for illustrated works of late years, have been the means of rendering this, as well as other matters of detail in the engraver's art, much more certain.

To imitate *chalk drawings*, a mixture of varied and irregular dots are used, made more or less soft, so as to resemble the grain produced by the chalks on paper. Every stroke of the chalks on paper may be considered as an infinite number of adjoining points, which are the small eminences of the grain of the paper touched by the chalk in passing over it. When the copper-plate has been properly prepared with etching ground, as in the common method of engraving, the drawing to be imitated may be counterproved on the ground of the plate. If this cannot be conveniently done, black-lead pencil or red chalk must be applied to varnished or oiled paper, and this chalk or pencil transmitted to the ground. The outlines of the object must be formed in the etching by points, whose magnitude and distance must be determined by the quality of the strokes in the original drawing. The artist may be provided with pointed instruments or needles of various sizes, with single or double points. In forming the light and shade, he should distinguish between those hatches which serve to express the perspective of the object, and those which form the ground of it. The principal hatches should be more strongly marked; the middle tints, if etched, should be marked lightly, or they may be left till the varnish is taken off, and be perfected with a greater degree of softness by needles, or the point of the graver, as the original may require. There is nothing peculiar in the method of applying the aquafortis in this kind of engraving; but it may be observed that it should not be left so long as to corrode too much the lighter parts. If the light parts are sufficiently corroded, they may be stopped up with turpentine varnish and lampblack mixed together, and the aquafortis may be applied again to the stronger parts; for it will be no detriment to them, if the points which compose the shade burst into one another, provided the extreme be avoided. When the work of the aquafortis is finished, and the varnish taken off the copper, it will be necessary in the softest parts, such as the flesh, to interstipple with proper points, as an effect will be thus produced more delicate than it is possible to attain with the aquafortis only; and the strongest shades will require additional strength to be given them with small strokes of the graver. Drawings made with chalks of different colours may be imitated in this manner, if a plate be provided for every colour. This method of engraving is intended to form a kind of deception, so that the connoisseur may not be able, on the first inspection, to distinguish between the original drawing and the engraving made in imitation of it; and it is extremely useful, as it serves to multiply copies of drawings left by those masters who excelled in the use of chalks, and thus to form and improve young artists, who could not have access to the originals in the practice of drawing.

To this account of the history and practice of the art of engraving we shall annex the following ingenious observations by an eminent artist.[1] We present them to our readers without alteration or abridgment.

On the linear art in general.

"When compared with painting, the art of engraving is but a recent invention, being coeval only with that of printing; and, like that noble art, it possesses not only a similar, but a greater power of multiplying and extending the productions of genius over the world, for its language is universally understood.

"It would have been well for the art if it could boast of a more remote date, as we might then have had many more of the finest designs of the first painters of antiquity, now doomed to oblivion, saved from the rude ravages of time.

"But this invention seemed to be reserved for the fourteenth century, and its improvements for the age of Louis XIV.; an age in which a number of artists, who may be said to have invigorated the art and invested it with beauty, arose both in France and Italy.

"Lines, in the first state of the art, like every other pursuit whose excellence is progressive, were comparatively rude and unmeaning, and had nothing more to recommend them than merely representing a particular sort of markings, or slight hatchings with the pen, without any other apparent degree of execution or expression; although it is our pride to acknowledge that it has been not a little beholden to the elegant etchings of the great masters in painting, as well as to their drawings in pen and ink in its early stages, by which means an eminent degree of taste was introduced into the art, particularly in the department of linear disposition; amongst those, the drawing of a Raffaelle, Michel Angelo, and the learned Da Vinci, some of which we have occasionally seen and admired. Some by Da Vinci were hatched in a square but delicate manner, with a white fluid, on dark-coloured paper. Those of Michel Angelo and Raffaelle inclined more to the lozenge, in black or brown ink. They even carried this style of hatching with the pencil into their pictures, some of which adorn the Vatican; and in the famous cartoons in his majesty's collection by Raffaelle. Baccio Bandinelli generally hatched his lines in one direction, particularly a Taking down from the Cross, which was sold in London at the sale of the late Sir Joshua Reynolds' drawings. Vicenzio Dante hatched in a similar way about the year 1550. Julio Romano used also to draw in this style with the pen, several of which are still to be found in the most select cabinets of men of taste; and for near a century and a half after the invention of etching, it is rare to mention a painter of eminence who was distinguished in drawings, who did not annex this art to that of painting. But with the application of the burin the art has been gradually improving till the present period. Linear[2] engraving is nothing more than drawing elegantly on copper. It became more studied as it was found capable of representing the various appearances of nature. The texture or surface of objects became proportionally discriminated by such peculiar modifications of the line as seemed most suitable to the subject represented, although, at the same time, it rendered it much more arduous in the execution. Hence arose that diversity of style, and that scope for succeeding excellence, which, by combining elegance with simplicity and beauty, distinguished those artists who have been most conspicuous in its improvement.

"It has been said that we are indebted for the origin of this art to an ingenious Florentine, Masso Finiguerra the sculptor. He was succeeded by a number of other ingenious men, among whom we rank Botticelli, Andrea Mantigna, and other able designers; and in Germany, Albert Durer, Aldgrave, and Lucas van Leyden, who severally contributed their labours. But in the fifteenth century the works of the divine Raffaelle began to be multiplied by the correct graver of Marco Antonio, an artist whose prints were the delight of that great painter. Antonio had many imitators, but none who equalled him for justness of contour, for which his works will be ever highly appreciated among the early productions of the art. Having had occasion to mention a few of the principal artists who reared the scaffolding of this elegant art, we shall proceed to those who have so much distinguished themselves in finishing the superstructure. Among those, Augustino of Venice began to introduce a better disposition of line in his shades, as well as the ingenious Bolognese, Augustino Caracci; whilst Egedius Sadelaer displayed no less zeal in Germany. In the sixteenth century the art displayed still more vigour and taste, and seemed to have but little more wanting; for all that meagre dryness of line began to disappear, which so manifestly marks the early works of Il Tedesco, Aldegraff, and other artists of a former period. Their works became consequently more rich in style, by embracing the best productions of the pencil; and as they were applied to a greater number of ideas, they became still more interesting and successful.

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[1] Francis Legat, Esq. historical engraver to George IV. when Prince of Wales, and F. A. S. E.

[2] The author has taken the liberty of adopting here the word *linear*, from its strict analogy to this mode of engraving, and with the approbation of some of the first professors, both in painting and engraving.

"Patrons were numerous and liberal; and it is but proper to remark, that the various artists, on their part actuated by a becoming zeal which was highly creditable to themselves, were indefatigable. This is a circumstance not less worthy of imitation than the many admirable monuments of the art which they produced. Few but admired the works of Masson, Poilly, Nantueil, and Rousselet; and some time after the death of the ingenious Cornelius Bloemart, who had given a grace to his lines hitherto unknown at Rome, the matchless Audran and Edelinck displayed their excellent productions at Paris. But arts are liable to fluctuate; and when the art of engraving began to decline abroad, it gradually displayed a high degree of lustre in our own country; and the variety of styles which has since sprung from the original manner of engraving, shall be the subject of the following sketch.

"We shall, therefore, treat more particularly of the disposition of the lines, and their consequent effects, distinguished by the terms *linear expression*, *imitation*, *disposition*, and *harmony*; with a strict investigation of the first and most approved subjects, either in etching or engraving, and of their essential beauties, as far as they may tend to illustrate the subject.

"As the great object of this mode of engraving is to adopt those lines the most expressive of the form and character of whatever happens to be represented, it is necessary to begin by maturely investigating not only the action, but the cause and correspondent effects, of the original picture, in order that the artist may avail himself of all that is most beautiful in his translation, and efficient in the aggregate, either with respect to the expression, spirit, or sentiment.

n linear xpression ad dispo- tion,

"When historical subjects consist of several figures where there is generally a variety of draperies, some of them appearing thick and cumbersome, others more thin and flexible, sitting close and elegant on the limbs, being composed of a finer texture or thread; the coarser stuffs are consequently more effectually represented by a bolder line, as the thinner sort, by the application of a fine line, gives a more lively representation; a discrimination which has been observed of late by the most approved modern artists in linear engraving. Observations of this description, when treated in a liberal manner, not only superadd a degree of truth, but even render the subjects sweeter to the eye of fancy. In the early stages of the art some excellent artists have been led into particular and limited systems. In the works of such as have affected to describe every subject in the same line indiscriminately, even the arms of the most delicate women are often engraven as if perfectly polished, by approaching to a metallic appearance, a mode not uncommon among the second or third class of artists about the beginning of the last century; by which manner all that softness and delicacy was neglected which is so happily effected in the linear productions of Strange, Bartolozzi, Morgan, Sharp, Heath, and others. Those who are acquainted with the works of the ingenious Chaffard, must with pleasure have perceived in his foliage how even the texture of flowers is imitated from the delicate line-like fibres of which they are composed, issuing from the stem and spreading their silken beauties to the sun; and in this class of imitation, the clear transparency of glass, the rough texture of woollen, the thinness of lawn, the flickerings of satin, or the lightnings of steel, as well as the rude rock, the lucid lake, or the flashing of the torrent, are all admirably adapted to linear effect by the almost infinite diversity in their construction and general constituent principles, strictly observing on what laws the beauty of lines consists, by ever keeping in view the due balance of taste, and a noble simplicity of style throughout. It is the business of the skilful artist to overpower and subdue the difficulties in his profession; for no excellence in art is of cheap or vulgar acquisition. Let it be remembered, that with forming steel even the enchanting graces of the Venus de' Medicis were hewn from a rock, and the almost breathing Apollo from a block of Parian stone.

"An elegant English poet, in a critical essay on poetry, observes that the sound should seem an echo to the sense; so should the lines in a fine print seem to harmonize with the subject, by flowing with the external cast of the features, and the predominant passion expressed in the original picture; for the same character and disposition of the lines that suit the action of the muscles in one passion, will be found to appear more vacant and less expressive when applied to others, however graceful they may appear.

"As this is a point of view to which the art has never yet been fully extended, perhaps it may meet with some degree of attention, as it will be found of utility in forming a principle respecting disposition, more particularly in historical subjects, where the passions are required to be nicely expressed; and although it may admit of some slight exceptions, it is a principle that will in general be found to be true.

"For example, let it be supposed that the passion of the figure represented is that of joy, the lines should seem to expand and swell, with every acting muscle, in the most delicate manner possible.

"But, on the contrary, if the subject displays deep sorrow, they should rather incline downward, partaking somewhat of the half straight, seeming to act apparently in perfect unison and conformity with the features of the face, with all due subordination to the general effect of light and shadow.

"Various observations may be made in this manner on the principal passions expressed in the human countenance, which are but few comparatively, even from the slightest movement to the boldest action. We often find, on examining the works of those masters who are not so conspicuous for great clearness of execution, that they have been occupied by the disposition and energy of the lines, as in the magnificent and masterly prints of the battles of Alexander, from the pictures of Charles le Brun, engraved by Gerrard Audran, where the executive department is no less conspicuous from the burin of the Chevalier Edelinck in the fine print of the tent of Darius; whilst Audran displays the true spirit of art, but rarely avails himself of much of the mechanical principles. The field and tumult of battle seemed admirably calculated to call forth his rapid powers, particularly in works of magnitude.

"The less active scenery of the tent of Darius was well adapted to the splendid talents of Edelinck, who was admirably qualified to display subjects of this nature. This is sufficiently obvious from the beautiful and interesting group of the queen mother, and her illustrious family, kneeling at the feet of the conqueror; his impressive print of the Magdalene, or his most admirable portraits of the dignified clergy, distinguished authors, and eminent artists. These, in point of engraving, are no less remarkable for taste in the execution, than for truth and nature in expression.

"In one of the battles of Alexander, the group where Porus is wounded and supported by the soldiers, the rough discrimination of line finely accords with that bold deportment of character in the grim visage of that gigantic prince, whilst a more delicate line marks the youthful countenance of Alexander; a discrimination which is totally lost in the large Dutch copy by De Vos.

"In the same print the figures of Alexander and Clytus are finely relieved from the distant scenery by the varied description of engraving on their armour, drapery, and horses. The latter are managed with such freedom and spirit, that it is difficult to say whether the horses or figures teem the most with masterly execution; particularly the white war-horse on the right extremity of the print.[1]

"Had Audran superadded a still greater portion of the delicacy and clearness of handling so conspicuous in Edelinck and other eminent artists since that period, it would undoubtedly have given an additional beauty to his other transcendent acquisitions; namely, the vast spirit of his lines, and power in drawing.

"But it is seldom the lot of an individual to combine every excellence. Arts too have their infancy, for they generally require the labour of ages to bring them to maturity and perfection; and it yet remained to unite and ameliorate the polish of Edelinck, to the spirited style of Audran. Without prejudice or partiality, a considerable degree of this excellence will be found in the best works of British art, as we shall hereafter exemplify.

"Another fine specimen of linear engraving, and of a different class, is the celebrated storm of Balechow, from a picture of the famous Vernet. In this print he has transmitted with the graver a certain fluidity and action in representing the liquid element, to which the art had never before attained. To a grandeur of style in the bold swelling of the waves he has superadded the utmost transparency of line; at the same time having attended to all that light restless spray which seems sporting to the gales as they roll along. In a fanciful mood one might almost imagine they heard the motion of the water; so finely did this discriminating artist translate this admirable picture.

"When we consider the period in which this distinguished work was engraved, and that little or nothing had been previously done in that department of a similar excellence, it is hoped it will be a sufficient apology for the degree of admiration here expressed; for, as Lord Verulam truly observes, "we are too prone to pass those ladders by which the arts are reared, and generally reflect all the merit to the last new performer." We have already observed, they are seldom reared with rapidity, and oftentimes that which is considered an invention is only a long succession of trials and experiments, which have gradually followed each other, and ought rather to be considered as a series of human mind than the knowledge of an individual, being the works of ages. In any point of view, the present subject will ever be considered as a high improvement and an elegant acquisition in the annals of the linear art. But in historical subjects this artist is by no means equal in point of taste or discrimination. His print of St Genevive undoubtedly ranks high in the first classes of engraving. Had his taste in other respects been equal to his powerful clearness of execution, it would have been almost unparalleled; but it betrays a want of that essential, even in his mode of thinking. Patience and labour are everywhere too prevalent. It remained for Woollet to excel both in figures and landscapes.

"In the various styles and modifications of this expressive art, from the neat to the feeble, and from the bold to the extravagant, taste stands sole arbitress; in brief, it is she who distributes variety with spirit, and conceals the appearance of intricacy and labour; who, by a due modification of line, unites clearness to softness, arresting the hand of the skilful artist from every effort inconsistent with her powers; producing at once to the mind all that agreeable finished combination or harmony which ever accompanies and constitutes the perfection of true art.

"In the execution of subjects of imagination, there is a perpetual scope for calling forth the fancy of the engraver, as the various combinations of lines are inexhaustible, uncommon effects, such as aerial spirits, or celestial beings blended with the light, or ghosts commingled with the gloom, or fairy elves by moonlight, who trip the sands, and yet no footing seen; or wood nymphs laving their taper limbs in the limpid element. Such subjects, in point of style, depend entirely upon the beauty, lightness, and transparency of execution; for those that are merely ornamental or grotesque demand a style of a different cast from that of the serious or historical, as they require a less degree of truth even from the burin. In these cases the style may be as capricious as the subjects. Those of Raffaelle, in the Vatican, display an uncommon degree of taste, and particularly in the elegant flow of line with which they are composed.

"In all works of taste and genius, those which may appear the most simple at a transient glance, will be often found to contain the most art on a more mature investigation. The first impression may strike the fancy, but the second generally calls up the discriminating powers of the judgment.

"Arts generally rise in our esteem according to the degree of exertion of the mental powers which they require; and, as lines are capable of various styles, those which are most congenial to the subject represented ought to be adhered to in preference to every other consideration. Teniers and Gerrard Douw demand all the fidelity and delicacy of the burin in describing the various draperies and individualities which belong to that class of painting; but, in proportion as the contour is composed of fewer parts, and the forms more full and elegant, the beautiful flowing qualities of the graver are increased, and its lines glide more gracefully over the figures, as may be found in the works of Strange and others, from Guido and Correggio. This distinction will not appear so obvious on a superficial view of the art. But, on a due investigation, it will be found, that not only a different modification of lines is necessary to the various classes of painting, but that even a different description of style is requisite to characterize some of the masters in each particular class, from the sublime and elevated figures of a Raffaelle and Michel Angelo, to the simple cottagers of Adrian Ostade.

"When we take a more comprehensive view of the art, we often find, that the styles which are adopted in the different countries in Europe by the artists where the art has in any degree been cultivated, are generally regulated by the modes of painting, drawing, and even the colouring respectively in each, whether historical, portrait, or landscape, and is proportionably appreciated according to the effective beauty and elegance of the execution.

"It is not improbable that the clear mode, which at present constitutes the modern German school, is a refinement on the simple style of Cornelius Bloemart.

"In Italy, Jachimo Frey, that astonishing Swiss, from his masterly expertness in drawing, and a rapid use of the etching steel and the nitre, almost produced an entire revolution in the art. The unprecedented richness and ease, the freedom and energy of his style, and the number and magnitude of his works, attracted all Italy, and tended

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[1] Whenever M. Bartolozzi happened to speak of those prints, he always expressed himself with a great degree of enthusiasm, thinking himself extremely fortunate in having works of such excellence in his possession.

greatly to improve the Roman school. About the year 1672 we find him working jointly with the nervous Dorigny Frezza, and Vanauden Aird. From this source we can perceive the style of Wagner, of Cars in France, and various masters now living; namely, Francisco Bartolozzi, Giovanni Volpato, Dominico Cunigo, and some of the early works of the excellent Raphael Morghen.

"In many instances Frey indicates, that if he had considered it of sufficient consequence to the art, he could have engraved with more clearness, particularly by his curious copy, from the celebrated print by Edelinck, of the Madona and Child, with St John and Angels, from Raffaelle; and, although but an imitation of another style, tends to show the versatility of his talents, when the judgment is for a while suspended to know which is the original. We find a performance of Frey's, entitled *La Charité Humaine*, dated 1723; a print was afterwards engraved from the same subject at Paris by Daulle, dated 1763, in which he has rather been too profuse in the more mechanical part of the art, and destitute of that ardour which a well engraved work should not only inspire, but maintain.

"It is not enough for lines to be only well disposed, but also full of expression; neither is it enough for a line to be only clearly cut, but it must also be free; for in a certain free light spirited lines convey an idea of animation, and are suited to subjects of that description; while the long, sweeping, and bold lines are better adapted to the solemn and majestic productions of the pencil.

"A fine print, like a miniature picture, ought to be viewed near the eye; as in itself, from the nature of the art, will be found a due subordination of effect, ever receding, from the bold and articulated lines in the fore ground, to those which are more evanescent and remote.

"The graceful birch, the mountain ash, and the oak, have each their peculiar bark and texture; and these, when freely indicated, stamp their mark and character most completely to the eye. Much of this, as has been formerly mentioned, depends upon, and is regulated by, the peculiar style of the picture and the skill of the engraver.

"As lines seem to partake of motion, in proportion as they deviate in gentle bendings from the straight and precise; even so also in the motion of water seemingly increased, whether they undulate with the simplest wave, or swell with the fierce and tempest-curled surge. This character is sufficiently illustrated in the works of Balechow and Woollet.

"In the late Mr Brown's large print of St John preaching in the wilderness, no engraver has ever more fully displayed the true spirit of Salvator Rosa, particularly in the original mode of treating the rocks, and the bold style of the surrounding scenery; in short, in the aggregate it is a chef d'œuvre unparalleled in any country. This is freely acknowledged, not only by every man of taste, but by the first landscape engravers.

"But Brown was perhaps less happy in the companion to the above, from the celebrated Both, by adapting a similar mode to that finished and delicate painter. For the style should ever vary with the subject.

> Whate'er Lorrain light touched with softening hue,
> Or savage Rosa dash'd, or learned Poussin drew.

"His admirable etchings of the cottager and its companion, and the Celadon and Amelia, are fine specimens of his discriminating powers, and characterized with so near an approach to truth, that we cannot help exclaiming with the poet,

> He sees no other, nature's self who sees.

"The engraving of the above subjects was finished by the matchless Woollet with the same happy taste. And it must be acknowledged that it is but seldom that we see so many excellencies united; for it is equally rare to see the finest engraving united to the finest drawing, as to find it in painting combined with the choicest colouring; yet each have their decided fascinations in the gallery, the cabinet, or the portfolio.

"Woollet, whose works abound with nerve and intelligence in point of character, his style of landscape is delightfully descriptive; whether rocks, water, trees, or sky; as the Niobe, the Ceyx and Alcyone, and other masterpieces from the great Wilson, evince. In the winter scene from Smith of Chichester he has admirably contrived to convey the effect of the drifted snow by delicate dotting; and with no less precision he has described the transparent ice with clear lines. Of trees, he was the first that ever faithfully characterized the graceful larch; as may be seen in his views of the noblemen's seats. In the print of the fishery he is indebted to the masterly etching of John Brown, particularly the shipping, in which there is perhaps no subject more articulate and perspicuous. The engraving of this subject is finished by himself. In his figures he was the founder of a style most happily adapted for modern dresses and historical portraiture; a style in which he moved with unrivalled reputation. His print of the death of General Wolf, painted by Mr West, is an admirable example, and does honour to the British nation. It occupied him no less than four years. The print of the battle at La Hogue is another fine specimen of his knowledge of linear discrimination. In short, when we consider the talents of this artist, it is difficult to decide whether he most excelled in modern history or landscape. The art has to regret that he, who was so eminently qualified to adorn any line of the profession, has left no works in ancient history. We have little doubt, from his knowledge, and a real love of the art, he would have left a sufficient monument in that department also for the pleasure and contemplation of the real connoisseur and of posterity. Engraving in this country sustained a heavy loss when he died; and if the death of so excellent an artist may be considered as a public loss, it is certainly the more felt with respect to Woollet, who died while he was yet improving in that excellence.[1]

"Chattelaine has been termed a mannerist in his drawings, but he must certainly be allowed to be an excellent one; his etchings are variety itself. Perhaps in the department of etching no artist has so happily translated the pictures of Claude de Lorraine as Francis Vivares; that is, with respect to aerial perspective, the peculiar characteristic of Claude. But his merits are not confined to this master alone; for he followed Ruysdale, Berghem, Gainsborough, and Cuyp, with great success. He has such a free delivery of style, that almost every one who examines his works is irresistibly impressed with an idea of performing the very same. Few artists, it has been mentioned, have excelled in the etching department. We cannot, however, omit the name of Peranezzi; who, to originality of style, which is apparently spontaneous, joins a certain grandeur which had never been surpassed. He has transmitted to posterity so spirited a representation of the Greek and Roman edifices and ruins, that travellers have often confessed that they have raised their ideas beyond the magnitude of the superstructures themselves. It is certain that in works of this stupendous nature, a degree of ruggedness in the execution corresponds with the sublimity of the subjects, and thus produces a still greater power over the mind than if they had been more polished. Some have censured his figures, and not without cause. This defect has been ingeniously palliated by an excellent artist, M. Bartolozzi. "For," said he, "if the purchasers of the works of Peranezzi get so much for their money in the building way, the figures may be supposed to be given for nothing." Doubtless those vast piles of perishing grandeur were never more judiciously presented to the eye than by this astonishing artist, or better calculated to affect the mind by calling forth its most sublime ideas.

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[1] Although we are now contemplating linear engraving, it is but proper here to observe, that chalk engraving, mezzotinto, and aquatinta, have also made ample improvements in this country in their various styles of excellence.

"We have another striking instance of spirited etching in a different pursuit of the art, in the works of Ridinger, a name which brings along with it all the savage scenery of nature.

> Assembling wolves in raging troops descend.........
> They fasten on the steed, and pierce his mighty heart.

For we shall ever find some peculiar beauty to admire, even in the slightest productions of genius, as well as in the most perfect productions of the burin.

"There are few artists who do not regret that etching was unknown to Bolswert, who has done so much without its aid; from which we may easily suppose how much more he could have effected with this charming acquisition. For the truth of this remark we may appeal to his landscapes from Rubens, his animated portraits from Vandyke, and his productions from the Flemish school of history, particularly his large print of the taking down from the cross, from Rubens.

"There is a fine instance of linear effect in a print of a Flemish conversation piece by Wille. One of the figures is drinking out of a glass, and the artist has most deceptively described the texture of the drinker's face through the glass. In the same print a female figure shows great skill in this way; even the floor is characterized by lines; and the whole strongly marks the most proper mode of treating subjects of a mere local nature. The beautiful print of the *Petit Physicien* is also an admirable imitation, particularly the little pellucid globule which has just mounted from the shell. When lines are engraved in a square acute method of crossing, they generally convey the idea of hardness to the subject represented. The scientific Picart seems to have been so much aware of this, that in a print of his engraving of a large marble group of horses, from the animated chisel of Perriere, he adopted this style in order to heighten the imitation.

"Mason's print of Marshal Harcourt is one of the many fine efforts of portrait engraving; and although it was executed at an early period of the art, it abounds with no small degree of taste. The celebrated print (called the table-cloth), from Titian, of the Last Supper, also contains a considerable degree of linear discrimination, although he sometimes carries it to affectation. He is rather singular in his mode of engraving hair. Yet the portraits of Marshal Harcourt and Brisasiere the secretary may be deemed exceptions.

"While, by the magic of his tooling, he is too apt at times to give his works indiscriminately the appearance of bronze; and we frequently find the same in the figures of Balechow; but it seems to have been reserved for Strange to give the softness of carnation to copper, and to Woollet to give force and clearness with discriminating taste; Bartolozzi in his lines, elegance, delicacy, and drawing; while the works of Audran teem with boldness and simplicity. In the prints of Sir Robert Strange, the greatest excellence is perhaps his rich and harmonious tones, as well as the whole effect, which is supported by an expressive style, which he seems in a great measure to have invented for his most favourite painters, Correggio, Titian, Guido, and Guerchino. The softness, the gusto, and the flowing draperies in the works of these masters, were his delight. His sleeping Cupid from Guido, and the prints of the Venus and Danaë from Titian, will ever be esteemed as *chef d'œuvres* in the linear art."

Having thus attempted to fulfil our original intention of discriminating the most expressive combinations of lines, and of analyzing and illustrating their various powers and effects in engraving, we shall now conclude these observations; and if, from the nature of the subject, and from the limits of the sketch, we have failed in marking every brilliant star in the galaxy of the art, it must at least be acknowledged that we have not omitted some of those of the first magnitude.

ENGRAVING *upon Steel.* On the first discovery of the art of printing from engraved metals, experiments would most probably be made with a view of ascertaining the fittest metal for the purpose. Indeed it is known that copper, tin, and silver were employed by the early artists; and there are some prints by Albert Durer which are considered as impressions from plates engraved or etched on steel. In the collection of Albert Durer's prints in the British Museum there are five of these prints, the chief of which are, *Christ in the Garden*, a print six inches by eight and a half, dated 1515; the *Lady and the Monster*, twelve inches by eight and a fourth, dated 1516; and the *Canon*, twelve and three fourth inches by eight and a half, dated 1518.

But, for the usual purposes of engraving, copper has, till within a few years, been supposed to have some advantages, which have led to its being nearly always employed in preference to other metals; and in one instance only have we found that steel-plate was used for engraving upon in this country, before the late attempts to prevent the forgery of bank-notes. The plate we allude to is the Ceiling of the Star Chamber, in the *Topographical Illustrations of Westminster*, engraved by Mr J. T. Smith in 1805.

The great expense of renewing plates for bank-notes, when any superior engraving is introduced for rendering imitation difficult, suggested the idea of employing a harder material than copper to engrave upon. Steel-plate was tried, and found capable of affording from twenty to thirty times the number of impressions that could be obtained from a plate of copper, whilst it was not much more difficult to engrave upon. The advantages derived from employing steel were first made public in this country in 1818, by the inquiry respecting the prevention of forgery, instituted by the Society for the Encouragement of Arts in London, when a specimen of engraving on soft steel was presented to the society by the late Mr Charles Warren; and it appeared from evidence collected by the committee, that notes with ornamental borders, printed from steel-plates, were then in use in America. Soon after this period Messrs Perkins and Fairman from America, in conjunction with Mr Heath, an eminent engraver of London, formed an establishment for printing notes and other engravings from steel blocks.

The methods of engraving on steel, adopted by Warren and others, were similar to those employed in engraving on copper; differing only as far as was necessary on account of the nature of the material and the process of hardening the plates in use in the earlier stages of this invention. In addition to these methods, Perkins, Fairman, and Heath employ a mechanical process for increasing the number of impressions. They first make the engraving on a thick plate of soft steel; the plate is then hardened, and the impression is transferred, in a spring press, to the surface of a soft steel cylinder, by rolling the cylinder repeatedly to and fro on the engraved plate, under a very considerable pressure. The transfer thus obtained is in relief, and the cylinder being hardened, it is made, by the same spring press, to repeat as many impressions as may be desired on soft steel, or on copperplates, for the purpose of printing from. They usually impress steel blocks, each of which will afford several thousand impressions; and when the cylinder becomes worn by transferring, a new one may be impressed from the original engraving; and, consequently, an inconceivable number of prints may be obtained from one original plate.

It ought, however, to be remarked, that an engraving cannot be transferred from steel to steel without injury; and that the injury will be greater in proportion to the delicacy of the work. Indeed, where engravings are to be considered as works of art, it will always be preferable to engrave or etch on tempered steel, and print from it without hardening. A sufficient quantity of impressions may thus be obtained, and of a superior kind; because steel being harder and more compact than copper, it is consequently less worn by the process of wiping off the printing ink either with the cloth or the hand.[1] But the power of transferring is of great value in all cases where a great number of impressions is the chief object desired, as in notes, plates for school-books, ornamental borders for pottery, labels, and the like.

In preparing steel-plates, either for engraving or etching, the surface should be well polished, so as to render it compact, of an equable degree of hardness, and perfectly smooth. The same tools are used as for copper, but they should be of the kind of steel which is endowed with the greatest degree of toughness. When a plate is to be etched, the point which removes the varnish should be sufficiently hard to penetrate the polish on the surface of the plate; the acid will then bite more freely, and to a greater depth, without spreading so as to produce a broad and shallow line. A point of diamond is, we believe, sometimes employed, particularly where the lines are drawn with the *ruling-machine* invented by Mr Wilson Lowry, the founder of a new school of engraving, which has been of infinite use in diffusing correct taste in architecture and sound knowledge in mechanics. The same ingenious artist observed, in the first etchings on steel, that the lines were broad without depth; and, in consequence, tried to find a *menstruum* which would answer the purpose better than the common acids. In this he perfectly succeeded, and was enabled to bite the lines deep, and yet preserve the desired degree of fineness.

Of the common acids, diluted muriatic acid seems to answer best, but diluted nitric and nitrous acids produce nearly the same effect.

When the graver is to be much employed on a plate, it should be annealed, in order to render it uniformly soft. The plate, after being engraved, may be hardened most effectually, and with the least injury to the engraving, or risk of warping the plate, by heating it in a metallic bath, and quenching the whole in a cooling fluid. A bath of the fusible alloy of lead, tin, and bismuth, which Dr Wollaston proposed for hardening delicate steel-work, will perhaps answer better than any other. (See Cutlery.) It will always be an advantage to employ a perfectly fluid medium for cooling; and we have reason to conclude, from some hasty experiments, that water heated to its boiling point is better than cold water for cooling steel. The quick abstraction of heat, by converting water into steam, seems to have more effect than the mere cooling power of a large body of cold water. Plates to be hardened should be about half an inch thick.

If plates are not to be transferred, there is some disadvantage in employing thick ones; and more especially in cases where an alteration may be necessary, or a mistake is to be rectified. In a thin steel-plate it is as easy to rectify an error as in copper; but in a thick one it is a very troublesome process.

Mezzotinto engraving on steel is also found to answer well; and upon that metal some very fine prints have lately been done; and the great number of impressions which a steel plate affords will cause this beautiful style of engraving to be more generally cultivated.

As printing from engraved steel is now much used as a means of preventing forgery, we shall close this article with a few remarks on that subject. It appears to us that there should be nothing complex in the figures which are selected for the engraving; their excellence should consist in the perfect evenness and parallelism of lines, whether straight or curved; but curved lines of difficult kinds should be preferred. Many crossings render a pattern intricate and confused; they distract the attention and dazzle the sight. Wavy patterns, with scattered lights, have the same effect. In such cases it is difficult to compare one specimen with another, and a general imitation is not so easily detected. It will be desirable to unite the work of an artist to that of a mechanical engraver; and in such cases the subject should be of sufficient size to allow of its being distinctly made out, because it will increase the difficulty of imitation. Where the circulation of notes is limited, good engraving on the note will be some check upon forgery; but the notes of different banks should be made as distinct as possible, instead of the same work being introduced in different notes, as may easily be done with steel cylinders. Where a whole empire is served with one kind of notes, the temptation to forge is so great that it cannot perhaps be altogether prevented; and, therefore, whilst every proper expedient should be used to increase the difficulty of forgery, no apparent difficulty of copying should render bankers and others less on their guard against it.

See *Report of the Committee of the Society of Arts, on the Mode of Preventing the Forgery of Bank-Notes*, 8vo, London, 1819; *Edinburgh Philosophical Journal*, vol. iii. p. 140.

Engraving *upon Glass*. See Glass, *Engraving on*.

Engraving *on Precious Stones* is the representing of figures, or devices, in relief, or indented, on various kinds of hard polished stones.

The art of engraving on precious stones is one of those in which the ancients excelled; there being various antique agates, cornelians, and onyxes, which surpass any thing of the kind which the moderns have produced. Pyrgoteles among the Greeks, and Dioscorides under the first emperors of Rome, are the most eminent engravers we read of. The former was so esteemed by Alexander, that he forbade any body else to engrave his head; and Augustus's head, engraven by the latter, was deemed so beautiful that the succeeding emperors chose it for their seal.

All the polite arts having been buried under the ruins of the Roman empire, that of engraving on stones met with the same fate. It was retrieved in Italy at the beginning of the fifteenth century, when one John of Florence, and after him Dominic of Milan, performed works of this kind no way to be despised. From that time sculptures of this kind became common enough in Europe, and particularly in Germany, whence great numbers were sent into other countries; but they fell far short of the beauty of those of the ancients, especially those executed on precious stones; for, as to those on crystal, the Germans, and after them the French, &c. have succeeded well enough.

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[1] A steel-plate, which had not been hardened, has been known to afford 95,000 impressions without material injury.

In this branch of engraving artists make use either of the diamond or of emery.

The diamond, which is the hardest of all stones, is only cut by itself, or with its own matter. The first thing to be done in this branch of engraving is, to cement two rough diamonds to the ends of two sticks large enough to hold them steady in the hand, and to rub or grind them against each other till they be brought to the form desired. The dust or powder which is rubbed off serves afterwards to polish them; and this is performed with a kind of mill that turns a wheel of soft iron. The diamond is fixed in a brass dish, and, being thus applied to the wheel, it is covered with diamond dust, mixed with oil of olives; and when the diamond is to be cut facet-wise, first one face, and then another, is applied to the wheel. Rubies, sapphires, and topazes, are cut and formed in the same way on a copper wheel, and polished, with tripoli diluted in water. As to agates, amethysts, emeralds, hyacinths, granites, rubies, and others of the softer stones, they are cut on a leaden wheel, moistened with emery and water, and polished with tripoli on a pewter wheel. Lapis-lazuli, opal, and some others, are polished on a wooden wheel. To fashion and engrave vases of agate, crystal, lapis-lazuli, or the like, a kind of lathe, like that used by pewterers, is made use of to hold the vessels, which are to be wrought with proper tools; that of the engraver generally holds the tools, which are turned by a wheel; and the vessel is held to them to be cut and engraved, either in relief or otherwise, the tools being moistened from time to time with diamond dust and oil, or at least emery and water. To engrave figures or devices on any of these stones when polished, such as medals, seals, and the like, a little iron wheel is used, the ends of whose axis are received within two pieces of iron, placed upright, as in the turner's lathe, and so adjusted as to be brought closer, or set further apart, at pleasure. At one end of the axis are fitted the proper tools, which are kept tight by a screw. Lastly, the wheel is turned by the foot, and the stone applied by the hand to the tool, and shifted and conducted as occasion requires.

The tools are generally of iron, and sometimes of brass: their form is various, but it generally bears some resemblance to chisels, gouges, and the like. Some have small round heads like buttons, others like ferrels, to take the pieces out, and others again flat. When the stone has been engraven, it is polished on wheels of hair-brushes and tripoli.

ENGUERA, a town of Spain, in the province of Valencia, with 5000 inhabitants. About 3000 weavers and spinners are employed in its manufactories of cloth.

ENGUICHE', in *Heraldry*, is said of the great mouth of a hunting horn, when its rim is of a different colour from that of the horn itself.

ENHARMONIC, in *Music*. See MUSIC.

ENIGMA. See ÆNIGMA.

ENKHUYZEN, a city of North Holland, in the circle of Hoorn. It is situated on the Zuyder Zee, and is strongly fortified both on the land and on the sea side. It contains 2600 houses and 6950 inhabitants, who carry on extensive fisheries, have considerable trade in cheese and wood, and refine much salt. It has considerable reputation for its horticultural products. Long. 4. 5. E. Lat. 52. 42. 22. N.

ENMANCHE', in *Heraldry*, is when lines are drawn from the centre of the upper edge of the chief to the sides, to about half the breadth of the chief, signifying sleeved, or resembling a sleeve; from the French *manche*.

ENNEAGON, in *Geometry*, a polygon with nine sides.

ENNIUS, Q., a celebrated poet of Rhudiæ, in Calabria, a province of the south of Italy, to the east of Tarentum, born 239 before Christ, in the consulship of Q. Valerius Falto and C. Mamilius Turrinus. Descended from one of the petty princes who ruled over this portion of Italy, he had inherited nothing from them except the barren nobility of blood. His early years, if not spent in the camp, must at least have been disturbed by rumours of war and threatened invasion. The inroad of Hannibal, 218 before Christ, and the fearful struggle which ensued between the two powerful nations of Rome and Carthage, could scarcely have taken place without extending its shock to the most remote villages of Italy. In the earlier period of the contest, we are ignorant of the side to which Ennius adhered; but we find him, in 204 before Christ, when he was thirty-five years of age, serving as a soldier in Sardinia, with such distinction as to attract the notice of Cato the elder, at that time commander of the island. By him he was brought to Rome, where his high character and literary attainments introduced him to the acquaintance of the most distinguished characters of that city. Scipio Africanus the elder became his intimate friend. At Rome he seems to have employed his time in extending the knowledge of the Greek language amongst the younger branches of the nobility. Even Cato did not disdain to become his pupil; and the example which he thus set no doubt tended much to divert the minds of his countrymen towards pursuits of a more refined and intellectual character than had hitherto engaged their attention. His genius procured him the freedom of the city, an honour which had not yet become worthless from an indiscriminate distinction. He passed into Ætolia, in 183 B. C., with the consul Fulvius, to whose care the war in that country was intrusted; and he no doubt seized this opportunity of visiting the various states of Greece. He seems, however, to have returned to Rome, where he died of the gout in 169 B. C., in the seventieth year of his age. Scipio, before he died, had expressed a wish that their bodies should rest in the same grave; and we know that a statue was erected to his honour on the tomb of the Scipios.

Ennius must be considered as the father of Roman epic poetry; and the eminent services which he performed for the literature of Rome were fully appreciated by ancient writers. Throughout his works there ran a strain of noble and passionate feeling. The language, though sometimes rough and unpolished, was full of power, and even of sublimity. The structure of the verse was more regular, from the introduction of hexameters, than that in which his predecessors had sung. The principal work, from which we have numerous fragments, was the *Annales*, an epic poem in eighteen books, in which Ennius sang the history of Rome, from its foundation till his own times. In another work, written in catalectic tetrameter, he celebrated the deeds of the elder Scipio. Besides, he had composed satires and other minor poems, which seem, however, to have been rather translations from the Greek writers: *Edesphagetica*, or *Phagetica*, in hexameters, a gastronomic poem after the Greek of Archestratus; several epigrams; *Epicharmus*, a didactic poem on the nature of things, in trochees and hexameters, from the Greek of Epicharmus; *Protrepticus*, of a moral nature; *Præcepta*, perhaps the same as the preceding; *Asotus*, or *Sotadicus*; also a Latin prose translation of the well-known Greek work of Euhemerus on the Gods; and perhaps in prose, a work on the Rape of the Sabines.

His tragedies seem to have been generally composed in imitation of the Greek dramatic writers, Æschylus, Sophocles, Euripides, and others. Those whose titles have been preserved to us are the following: Medea, Iphigenia (after Euripides), Achilles, Ajax (after Sophocles), Telamon, Hectoris Lustra, Alexander, Andromache, Hecuba, Eumenides (after Æschylus), Dulorestes, Erechtheus, Cresphon, Athamas, Andromeda, Telephas, Thyestes, Phœnix, Melanippa, Alcmæon, Cressæ, Alcestis, Nemea, Ilione or Polydorus, and Antiope.

The titles and fragments of several of his comedies have also been preserved, which, like his tragedies, are copied from the Greek dramatic writers of the new comedy. They are, Amphithraso, Ambracia, Pancratiastes.

The fragments of Ennius were published by Columna (at Naples, 1590), and again in the *Corpus Poetarum* by Hesselius (4to, Amstel. 1707). The fragments of the Annals were collected and published by P. Merula (Lugdun. Bat. 1595), and by Spangenberg (Leipsic, 1825). The tragedy of Medea was published in part, with a selection of other fragments, and a learned commentary, by H. M. Plauck. (Hanover, 1807, 4to.)

For a detailed account of the life and character of Ennius, the reader may consult W. Fr. Kreidmann *Orat. de Q. Ennio*, Jenæ, 1754; Krause, *Vitæ et Fragmenta veterum Historicorum Romanorum*, Berlin, 1833, 8vo; also Fabricii *Bibliotheca Latina* (1 vol. p. 664), Hamburg, 1721; also *Geschichte der Romischen Literatur* von Bahr, Carlsruhe, 1832.

ENORE, a village of Hindustan, in the Carnatic, eight miles north from Madras, and situated on the shore of a salt-water lake, abounding with oysters and other fish. It is a great resort of company from Madras, who meet here to fish, and to take the diversion of sailing in pleasure boats; an enjoyment which is quite impracticable on the coast, owing to the almost constant surf which beats upon the shore. The situation is on a flat sandy bank, where there are about a hundred native huts.

ENOS, a city of Turkey in Europe, in the district of the Sea of Marmora. It is on a river of the same name, but called by the Turks Boris Korfusi. It has a good harbour, frequented by ships of all nations, which take cargoes of wool, camels' hair, cotton, hides, morocco-leather, silk, copper, and wax. It is said to contain 7000 inhabitants. Long. 25. 56. 1. E. Lat. 40. 43. 42. N.

ENOTAEVSK, a town of Asiatic Russia, in the government of Caucasus, situated on the Volga, seventy-two miles N. N. E. of Astracan. Long. 46. 19. E. Lat. 47. 15. N.

ENOWTAWKAIA, a village and wooden fortress of Asiatic Russia, in the province of Astracan. The fortress was built in 1741, for the Kalmucs. It is twenty miles S. E. of Tchernoyar.

ENS, among metaphysicians, denotes entity, being, or existence. This the schoolmen call *ens reale* and *ens positivum*, to distinguish it from their *ens rationis*, which is only an imaginary thing, or exists but in the imagination.

ENS, a river in the Austrian dominions, which falls into the Danube. It is chiefly remarkable because it is the boundary line between two large provinces of that empire. These are distinguished by the names of the Upper and Lower Ens. The province of the Lower Ens is nearly in the centre of the monarchy. It is bounded on the north by Bohemia and Moravia, on the east by Hungary, on the south by Steyermark, and on the west by the Upper Ens. It extends over 8012 square miles, and is divided into four circles, besides one consisting of the city of Vienna and its suburbs. The names of those circles are, the Upper and the Lower Vienna Forests, and the Upper and the Lower Manhartsberg. In 1816 the province contained 1,045,412 inhabitants, who have increased considerably since that period, and occupied 35 cities, 339 market-towns, and 4286 villages, in which were 148,172 dwelling-houses.

The face of the country is generally mountainous, although the warm valley of the Danube and some others contain land equal to any of Europe in productive power, and spots whose picturesque beauty is excelled by few in any country. There are a great number of smaller streams which empty themselves into the Danube, the banks of all which are fertile and pleasant. The mountain ranges are a part of the Noric Alps, running for the most part perpendicular to the river, and varying in height from 4400 to 6500 feet. The soil varies greatly, and as a whole, including the mountain districts, cannot be considered as fertile. The surface of the province appears by the cadastre to be 5,023,580 English acres, and the rivers, lakes, roads, rocks, and waste lands, with the site of the cities, towns, and villages, occupy 1,046,860, or somewhat more than one fifth of the whole. The rest of the land is thus appropriated: 2,244,508 acres are under the plough, 96,757 are in gardens, 137,656 are in vineyards, 666,900 are in meadows, 467,254 in upland pastures, and 1,505,440 are woods and forests. Although agriculture is not worse conducted than in Germany generally, the product of corn is unequal to the demand for it; and it is calculated that wheat and rye scarcely yield more than five times the seed. The breeds of cattle are by no means good, and neither sheep, oxen, nor cows, are abundant. Poultry and river fish are plentiful, as are also game both of the feathered and four-footed kinds. Wine and fruits are copiously produced, and much of both, after supplying the capital, is sent to the other provinces. The want of wood for fuel is complained of, and said to be constantly increasing, although of late years improvements have been introduced in the management of the woods, roads made to many places that were before inaccessible, and floats formed on many of the small rivers, to augment the supply. The whole province is a manufacturing district, and furnishes cotton, linen, and woollen cloth, silk goods, iron and copper wares, gold, silver, and plated articles, glass, hats, paper, hosiery, and the various smaller articles of necessity or luxury. The chief commodities exported are wine, saffron, mustard, and wool. The imports consist of East and West India articles, silk, corn, flour, cattle, wood, and salt. The city of Vienna has good roads from it to the most distant parts of the empire, on which, as well as on the rivers, there is a very great traffic.

Province of the Upper Ens.

The province of the Upper Ens is the westernmost part of the Austrian dominions, with which have been incorporated a part of the Valley of the Inn, which, before 1779, belonged to Bavaria, and the larger portion of the duchy of Salzburg, ceded to Austria in 1816. It is bounded on the north by Bohemia, on the north-east by the province of the Lower Ens, on the south-east by Steyermark, on the south by Illyria, on the south-west by the Tyrol, and on the north-west by the kingdom of Bavaria. It is 7568 square miles in extent. It is divided into five circles, namely, the Mühlvierthal, the Hausruck, the Traun, the Innvierthal, and the Salzach or Salzburg. It contained in 1816 seventeen cities, 122 market-towns, 7725 villages, and 124,606 houses, inhabited by 756,890 individuals, since which they have rapidly increased.

The southern part of the province is a mountainous district, covered with a portion of the Noric Alps, in which are Glockner on the frontier of the Tyrol, 11,700 feet in height; the Viehbachhorn, 11,058; and several others exceeding 8000. Some of them are covered with perpetual snow, and have between them glaciers or fields of ice of more than sixty square miles in extent. On the north of the province the mountains which separate it from Bohemia are lower, but fill almost the whole circle of Mühlviertḥal. The province is well watered, having, besides the Danube, four other navigable rivers which discharge their waters into it. No country presents more lakes, and none are of greater beauty than the Traun, the Kammersee, the Mondsee, and the Hallstadtsee.

A country so mountainous has little opportunity of practising agriculture, and, with the exception of Salzburg, the corn is not supposed to produce more than four times the seed. The province contains 5,751,900 acres, of which 1,464,750 are under the plough, 44,840 are in gardens, 145 in vineyards, 649,967 are meadows, 1,393,670 upland pasture, and 1,697,040 woods. The remainder is occupied with lakes, rivers, glaciers, roads, and sites of cities and towns. One of the chief productions of the province is salt, which is made from brine springs upon a very extensive scale at Hallein. In some parts are mines now worked. These produce annually 2400 ounces of gold, 6400 ounces of silver, 886 quintals of copper, 490 quintals of lead, and 14,461 quintals of iron, besides arsenic, vitriol, sulphur, and gypsum. The iron manufactures, and particularly that of knives, give employment to thousands of families. There are also many mills on the various streams, for spinning cotton, linen, and woollen yarn. It is said that the woollen manufacture alone supports more than 25,000 families. In the cities of Lintz, Salzburg, and Steyer, there is much transit trade, both by the rivers and by the three great and excellent roads which traverse the province.

Ens, a city of Austria, in the province of the Lower Ens. It stands near the influx of that river into the Danube, and contains 380 houses, with 2951 inhabitants employed in linen weaving and in breweries. Being on the great road to Vienna, it has upwards of twenty inns and hotels. Long. 14. 21. E. Lat. 48. 13. N.

ENSEELED, in *Falconry*, is said of a hawk that has a thread drawn through her upper eye-lid, and made fast under her beak, to take away the sight.

ENSHAM, a town of the county of Oxford, in the hundred of Wootten, sixty-one miles from London. It is situated on the river Isis or Thames, and on the great road from London to Worcester and Birmingham, from which it derives some traffic. It had formerly an extensive abbey, the remains of which may still be traced. The population amounted in 1801 to 1166, in 1811 to 1418, in 1821 to 1705, and in 1831 to 1858.

ENSIGN, in the military art, a banner or colours under which soldiers are ranged, according to the different companies or parties to which they belong.

The Turkish ensigns are horses' tails; those of the Europeans are pieces of taffety, with divers figures, colours, arms, and devices thereon. Xenophon tells us that the ensign borne by the Persians was a golden eagle on a white ground; the Corinthians bore the winged horse or Pegasus on theirs; the Athenians an owl; the Messenians the Greek letter M; the Lacedæmonians the Λ. The Romans had a great diversity of ensigns, the wolf, minotaur, horse, boar, and at length the eagle, where they stopped. This was first assumed in the second year of the consulate of Marius. A military ensign on a medal of a Roman colony denotes it a colony peopled with old soldiers.

Ensign is also the officer who carries the colours, being the lowest commissioned officer in a company of foot, subordinate to the captain and lieutenant.

Naval Ensign, a large standard or banner hoisted on a long pole erected over the poop, and called the *ensign staff*. The ensign is used to distinguish the ships of different nations from each other, as also to characterize the different squadrons of the navy. The British ensign in ships of war is known by a double cross, viz. that of St George and St Andrew, formed upon a field which is either red, white, or blue.

ENT, Sir George, an eminent English physician, born at Sandwich, in Kent, in 1604. He was educated at Sidney College, Cambridge, and, having afterwards travelled into foreign countries, received the degree of doctor of physic at Padua. After his return he obtained great practice, was made president of the college of physicians in London, and at length received the honour of knighthood from King Charles II. He was extremely intimate with Dr Harvey, whom he learnedly defended, in a piece entitled *Apologia pro Circulatione Sanguinis, contra Æmilium Parisanum*. He also published *Animadversiones*, and some observations in the Philosophical Transactions. Glanville, speaking in his *Plus Ultra* of the modern improvements in anatomy, numbers Sir George Ent, Dr Glisson, and Dr Wallis, with the most celebrated discoverers in that science. The two former were amongst the first members of the Royal Society. Sir George Ent died in October 1689.

ENTAIL, in *Law*. See Tailzie.

ENTHUSIASM, in a religious sense, implies a transport of the mind, by which it fancies itself inspired with some revelation, impulse, or the like, from heaven. "In all ages," says Locke, "men in whom melancholy has mixed with devotion, or whose conceit of themselves has raised them into an opinion of a great familiarity with God, and a nearer admittance to his favour than is afforded to others, have often flattered themselves with a persuasion of an immediate intercourse with the Deity, and frequent communications from the Divine Spirit. Their minds being thus prepared, whatever groundless opinion comes to settle itself strongly upon their fancies is an illumination from the Spirit of God; and whatsoever odd action they find in themselves a strong inclination to do, that impulse is concluded to be a call or direction from heaven, and must be obeyed. It is a commission from above, and they cannot err in executing it. This I take to be properly enthusiasm, which, though arising from the conceit of a warm and overweening brain, works, when it once gets footing, more powerfully on the persuasions and actions of men than either reason or revelation, or both together, men being most forwardly obedient to the impulses they receive from themselves."

ENTHYMEME, in *Logic* and *Rhetoric*, an argument consisting only of two propositions, an antecedent, and a consequent deduced from it. The word is Greek, ενθυμημα, formed of the verb ενθυμεισθαι, *to think, conceive*, a compound of εν, and ϑυμος, *mind*.

The enthymeme is the most simple and elegant of all argumentations, being that which a man, in arguing closely, commonly makes, without attending at all to the form. Thus, the verse remaining of Ovid's tragedy entitled *Medea* contains an enthymeme: *Servare potui, perdere an possum rogas*,—"I was able to save you, consequently to have destroyed you." The beauty would have been lost had all the propositions been expressed; the mind is displeased with a rehearsal of what is nowise necessary.

Sometimes also the two propositions of an enthymeme are both included in a single proposition, which Aristotle calls an *enthymematical sentence*, of which he gives this instance: *Mortal, do not bear an immortal hatred.* The whole enthymeme would be, *Thou art mortal, let not, therefore, thy hatred be immortal.*

ENTLIBUCH, a bailiwick in the canton of Lucerne, in Switzerland, extending over 110 square miles, and containing five parishes, with 12,550 inhabitants.

ENTOMOLOGY.

Definition.

Entomology (from ἔντομον, *insect*, and λογος, *discourse*), is that branch of natural science which treats of the history and habits of the insect tribes. Its subjects are the most numerous and diversified of any of those topics which engage the attention of the student of nature; and as they exemplify in a most surprising and admirable manner, both by their structure and instincts, the wisdom of the author and creator of all things, and form a highly interesting department of human knowledge, we deem their elucidation deserving of a lengthened dissertation.

The English term insect is no doubt derived from the Latin word *insectum* or *intersectum*, signifying *cut into* or intersected, in allusion to the obvious divisions of head, thorax, and abdomen, of which their general forms consist. The Greek word bears the same signification.

CHAPTER I.

DEFINITION OF INSECTS—THEIR ORDERS EXPLAINED—AND THEIR STUDY DEFENDED.

In the article Animal Kingdom of this work (see vol. iii. p. 179), we have given a view of the primary divisions of the subjects of zoological science. The third primary division, that of the articulated animals, consists of four great classes:—1. *Annelides*, such as serpulæ, nereids, leeches, earthworms, &c.; 2. *Crustacea*, such as crabs, lobsters, and shrimps; 3. *Arachnides*, such as spiders, scorpions, and mites; and 4. *Insecta*, or true insects, such as beetles, butterflies, and moths. The class Insecta of Linnæus included not only those last named, but also Crustacea and Arachnides, and was thus almost co-extensive with what we now regard as a primary division under the term *Articulata*. We have, however, already discussed those two branches as distinct classes, under their respective titles (see Arachnides and Crustacea), and we shall not repeat the important characters by which they are distinguished from genuine insects.

The term insect was anciently applied to a much more extended series of beings than are now included under that designation. It seems to have comprised whatever was destitute of an internal skeleton, and exhibited a body composed of articulated parts. In this sense it accords with its application in the writings of Aristotle and Pliny, with certain restrictions however, for these authors were in advance of their successors, in as far as they distinguished the Crustacea from insects. Swammerdam and Ray adopted the definition of the ancient authors, but erred in classing the Vermes or worms with insects, a combination which does not appear for certain to have entered into Aristotle's views. Linnæus wisely separated these two classes, but at the same time injudiciously joined the Crustacea with insects, placing them in his order *Aptera*, along with spiders and scolopendræ. Fabricius in that respect followed the same general plan, and included all those living creatures in the same class, notwithstanding the better example shown by Brisson, who had separated all the species possessed of more than six feet, that is, the Crustacea and Arachnides of Lamarck. Since the death of the great Swedish naturalist, our improved knowledge of the anatomy and physiology of the invertebrated classes has thrown a clearer light upon the subject, and many modifications have taken place in the arrangement of the insect tribes.

Insects, properly so called, may be defined as *animals without vertebræ, six-footed, with a distinct head furnished with two antennæ and a pair of composite immoveable eyes, and breathing through stigmatic openings which lead to interior tracheæ.*[1]

As we shall have occasion to mention many terms which may not be familiar to the general reader, we deem it advisable, instead of taking his knowledge for granted, to commence with a brief enumeration and explanation of the various *orders* in Entomology, so that their names, when subsequently brought forward, may be associated with some definite idea. We shall consider all insects as included under eleven different orders, as follows.

1. Coleoptera (from Κολεος, *a sheath*, and πτερα, *wings*), including all those kinds commonly called *beetles*. Their membranous wings, which are the true organs of flight, are protected by a superior and anterior pair of harder consistence, called elytra. They are all masticators, and are provided with mandibles and maxillæ. Plates CCXXI–VII.

2. Orthoptera (from ορθος, *straight*, and πτερα, *wings*), including crickets, grasshoppers, locusts, &c. The upper wings are of the consistence of parchment, reticulated, and more or less incumbent. The mouth is provided with mandibles and maxillæ. Plate CCXXVIII.

3. Hemiptera (from ἡμισυ, *the half*, and πτερα, *wings*), including the cimices or bugs, the water scorpions, cicadæ or froghoppers, aphides, &c. A portion of their upper wings is frequently membranaceous, or of the same consistence as the inferior pair. The mandibles and maxillæ are replaced by a sheath and sucker. Plate CCXXIX.

4. Neuroptera (from νευρον, *nerve*, and πτερα, *wings*), including libellulæ or dragon-flies, ephemeræ, &c. Both pairs of wings are membranous, naked, and finely reticulated. Mouth adapted for mastication, and furnished with mandibles and maxillæ. Plate CCXXX.

5. Hymenoptera (from ὑμην, *a membrane*, and πτερα, *wings*), containing wasps, bees, ichneumon-flies, &c., and characterized likewise by membranous naked wings, which

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[1] The above definition excludes those many-footed species called *Juli* and *Scolopendræ*, which, though still included by some modern writers among insects, were established as a distinct class by Dr Leach (*Edinburgh Encyclopædia*, vol. viii.; and *Linn. Trans.* vol. ix.) under the title of *Myriapoda*, and were recognised as such by Latreille in his *Familles du Règne Animal*, p. 322. Although we did not allude to this class in our exposition above referred to (art. Animal Kingdom), we think that the removal of the two genera just named from the Insecta is advisable, as it leaves the latter in a state to be more clearly defined, as well as actually composed of more natural constituent parts, or, as MM. Audouin and Milne Edwards have expressed it, *plus homogène*. "En effet," say these authors, "tous les animaux qui la composent alors ont le corps divisé en trois parties distinctes, une *tête*, un *thorax*, et un *abdomen*; trois paires de pattes sont fixées au thorax; souvent deux ou quatre ailes sont suspendues à la même partie; la tête porte deux *antennes* et deux yeux immobiles; la bouche est garnie d'une serie d'appendices modifiés pour broyer les alimens solides, ou pour pomper ceux qui sont liquides; un système particulier de vaisseaux sert à la respiration, et porte le nom de *trachées*; il existe un vaisseau dorsal qui n'est autre chose qu'un cœur rudimentaire; mais il n'y a point de véritable système circulatoire; les sexes sont distinctes; enfin, la plupart de ces êtres éprouvent, pendant les premiers temps de leur vie, des métamorphoses plus ou moins complètes; mais jamais ils n'acquièrent, après leur sortie de l'œuf, de nouveaux segmens à leur corps." (*Résumé d'Entomologie*, p. 12.) All true insects, then, are *hexapod*, or *six-footed*; and the few genera now or lately classed with them, but of which the amount of feet is greater than six, belong to the Myriapoda,—under which term the reader, in due time, will find their history and classification.

Definition.

however, present fewer nervures, and are not reticulated, as in the preceding order. The mouth is furnished with mandibles and maxillæ, and the abdomen of the female is terminated either by an ovipositor · or sting. Plates CCXXXI–II.

6. Lepidoptera (from λεπις, *a scale*, and πτερα, *wings*), containing all butterflies and moths, and generally characterized by the farinaceous or scaly aspect of the organs of flight, and the tubular or thread-like extension of the parts of the mouth. Plates CCXXXIII–VII.

7. Strepsiptera (from στρεψις, *a turning* or *twisting*, and πτερα, *wings*), including a few peculiar and parasitical species belonging to the genera stylops and xenos. This order corresponds to the *Rhipiptera* of Latreille, but we adopt Mr Kirby's denomination, as possessing a prior claim. Plate CCXXXI.

8. Diptera (from δίς, *twice* or *double*, and πτερα, *wings*), including the house fly, and other two-winged kinds. The mouth is furnished with a proboscis, and there are two organs called poisers or balancers (*halteres*) placed behind the true wings, one on each side. Plate CCXXXVIII.

9. Suctoria (so designated from their sucking propensities) is constituted by the genus *Pulex* of Linnæus, and differs from the ensuing apterous orders in undergoing a regular metamorphosis, and possessing what some regard as the rudiments of elytra.[1] Plate CCXXXIX. fig. 13, 13 *a*, 14, 14 *a*, 14 *b*.

10. Thysanoura (probably from θιαζω, *to dance*, and ουρα, *tail*),[2] likewise an apterous order, including the *Poduræ* and other tribes. Plate CCXXXIX. fig. 7, 8, 12, and 12 *a*.

11. Parasita (so named from their parasitical or adhesive propensities, because they dwell on the bodies of other animals) contains the genus *Pediculus* of Linnæus, and the *Nirmi* or bird-lice.[3] Plate CCXXXIX. fig. 10, 11, and 11 *a*.

The study of the structure and habits of this numerous and diversified class of beings has long been a favourite occupation with men of science in all the continental countries of Europe, and has assumed of late years in the southern parts of our own island a character of considerable and increasing importance. Works have been recently published in this country which need fear no comparison with the most finished examples of pictorial representation; and when we consider how sparingly the subject of Entomology has been hitherto patronized by the public, we cannot sufficiently esteem the exertions of those who have thus devoted their time and talents to a pursuit which brings with it no other reward than the delight which every instructed mind necessarily draws from the contemplation of a favourite subject. Entomology, in truth, still stands in a difficult and somewhat dubious position, and presents itself to many under a far less inviting aspect than its beautiful sister-science of Botany. In connection with the latter study, the very mass of mankind, even the *profanum vulgus*, however ignorant of the technical details, have many early formed, and therefore pleasing associations. Every country-house has its flower parterres, and numerous cottages their glowing borders,—botanic gardens have been formed in the vicinity of most of the larger cities, while nursery grounds are frequent in the neighbourhood even of provincial towns, —to say nothing of the "flower enamelled meads" which each sparkling spring and gorgeous summer calls into fleeting but constantly renewed existence. In addition to the more attainable nature of this popular pursuit, some botanical knowledge is also regarded as a requisite branch of medical education; and although a tin box and a microscope do not constitute a man of science, still the subject derives advantage from that general though it may be superficial culture. But in Entomology every thing exists in a different order of relation. No "trivial fond regards" come in aid of the impaler of insects; and even the creatures themselves are too often regarded with such abhorrence, that one feels the more inclined to admire how those who endeavour to hand them down to an ungrateful posterity, should themselves be accused of cruelty.

The time however is surely gone by when an apologetical defence of the study might be required, or in which the works of Omnipotence were regarded as important in proportion either to their magnitude or immediate subservience to the human race;—and although we desire not to fall into an opposite error by maintaining the greater beauty and excellence of the more minutely elaborated designs of the Creator, we yet feel that they are fully more calculated to awaken our wonder and admiration. It would be easy to say that the richest and most elegant apparel which adorns the human race is the product of a caterpillar; that the blistering medicines so essential to the practice of the sanitory art are compounded from a beetle; that honey and wax, so valuable as articles of domestic economy, are derived from the glad labours of a hymenopterous fly; and that even that splendid and regal dye the "Tyrian purple" of ancient days, supposed to have been obtained from the *Purpura patula*, a shell-fish of the Mediterranean, is superseded by the tinctorial uses of the cochineal, a small and obscure insect, which nevertheless the skill of the chemist has rendered indispensable even to the garment of kings. But in truth far higher and more delightful results ensue from these researches, than can ever be named in the "cui bono" catalogue of a mere economist; for whatever tends to elevate the mind of youth above the grosser pleasures of sense, or even occasionally to disconnect our maturer years from the more turbulent occupations and harassing cares which life is heir to, assuredly carries along with it its own reward. We doubt not that a more sedulous and frequent attention to natural history would in active minds pre-occupy the place which is otherwise in after years too often devoted to more perilous courses. Even the pursuits of literature are often vague and objectless, and not unfrequently engender a sickly sentimentalism, or other morbid affection in nowise akin to genius. But the objects which attract the attention of the naturalist are not the melancholy creations of the human intellect, which present so often but a lurid brightness, or a dim eclipse, in which noble thoughts are obscured by the "darkening scales" of vice or folly. They are the work of Him who cannot err, and who has doubtless not only peopled the teeming earth and the translucent waters of the "great deep" with all their innumerable and varied wonders, for a wise and beneficent purpose, of which our instruction and amusement form at least a portion, but has, by the implantation of that strong instinctive love of nature which all ingenuous minds possess, demonstrated his desire that we should ennoble our humanity by magnifying his manifold works, the "wondrous works of him that is perfect in knowledge."

While the beautiful simplicity and regular order observable in those phenomena which proceed under the superintendence of omnipotence, commonly called the operations

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[1] This suctorial order is named *Aphaniptera* by Mr Kirby, from αφανης, inconspicuous, because there is an appearance of something resembling elytra.

[2] In allusion, we presume, to the springing propensities of the insects of this order, which leap by means of a setiform process bent beneath the abdomen.

[3] Those who assume the occurrence of marked transformations as a basis for the grouping of the orders, will rank the first nine of the above as *Metabola*, or insects undergoing metamorphosis, and the last two as *Ametabola*, or insects undergoing no metamorphosis.

Definition.

External Anatomy.

of nature, are well adapted to the comprehension of understandings laying no claim to the highest order, the more complex relations of the subject present a vast field for speculative or theoretical exercise, sufficient to occupy the faculties of the most powerful minds. It is thus that, in its totality, the subject of natural history holds out to each capacity the allurement of an occupation suited to every gradation of intellectual power; for while in its mysterious interconnection with other branches of natural science, as well as in its own peculiar complexities, it cannot be effectively grasped by mere human understanding, its manifold minor features may be scanned with intelligence by whoever desires so to do.

If indeed the value of a pursuit is to be estimated by the comparative ease with which it may be followed by persons of the most moderate fortunes, few can rank higher than Entomology. While the specimens sought for by the mineralogist and student of geology are frequently heavy and cumbrous, and not seldom extremely expensive, and while that sad representative of the beauties of the living Flora, called a *Hortus Siccus*, is but a frail and fleeting memorial of the "days of other years," presenting, even after a tedious and troublesome process of preservation (by courtesy so called), no trace of their original brightness, the most exquisite examples of entomological beauty, if not too roughly handled at the period of their capture, remain, with the most ordinary attention, for a lifetime in their pristine state,—and what that state actually is, all may satisfy themselves in the course even of the most superficial examination,—

> ....For nature here
> Wantons as in her prime, and plays at will
> Her virgin fancies.

Exceeding in amount of species all the other subjects of zoology,—unrivalled in the dazzling brilliancy of their colours, which combine the clearness and decision of tint possessed by flowers, with the exquisitely varied markings of the feathered race, and the metallic splendour of the mineral kingdom,—surpassed by no other work of creation in the wonderful structure of their parts, and certainly surpassing all in the adaptation of that structure to the perfect fulfilment of those natural though to us still mysterious instincts, which in every age have excited the admiration of mankind,—is it to be wondered at that the study of insects should occupy a prominent place in our pursuit of knowledge? Much more do we wonder that thousands of the best educated, and in other respects most enlightened minds, should still feel averse to a study which unfolds such a world of unseen wonders.

The subject, too, is literally inexhaustible; and while some who love to methodize, and thereby to circumscribe, the subjects of human knowledge, or who err in their estimate of the perceptive powers of the human mind as applied to other matters of enquiry, may be deterred by the vague boundaries of such a field, a greater number, and with more propriety it is hoped, may be induced to enter it, from the very consideration of such a rich and unreaped harvest. While a fragment of inert matter, which chemical analysis determines to differ in its constituent proportions from other fragments previously examined, is once in a lustre dignified by the name of a new *species*, and the name of a Haüy or a Dolomieu is bestowed on the unconscious mass,—and while, even in the richer domain of British botany, the student of that science, however much he may extend our knowledge of the localities of plants, labours with but a feeble chance of adding to the actual list even of indigenous species, and has probably no chance at all of ever refreshing his eyes with the sight of a plant which nobody ever saw before,—it is far otherwise with the innumerable tribes of insect life. The "gilded summer flies" are numerous as leaves in Vallumbrosa. No recess of the forest so obscure but there the "winged messengers" are seen to sport and play; and each summer sunbeam falls not alone on the dewy herbage of the open glades, but lights up the gorgeous hues of those bright creatures which a mystical philosophy has ennobled as the types of the disencumbered human soul, and which even the sombre Dante has named *angelical*.

> Non v'accorgete voi, che noi siam vermi
> Nati a formar l'angelica farfalla.

Every pool of water is pregnant with life; each lonely moor or old deserted quarry, which scarcely "feels in its barrenness one touch of spring," is the chosen abode of thousands of living creatures, of small dimensions it is true, but of singular beauty both of form and structure, and often adorned with hues,

> Which make the rose's blush of beauty pale,
> And dim the rich geranium's scarlet blaze.

Even the pastoral melancholy of the green mountains is enlivened by the occurrence of many interesting species. One of the most beautiful of European coleopterous insects (*Carabus nitens*) occurs among the peat *hags*, and other places where heath and turf abound, and where its sparkling coat of gold and green, tinged with a brighter lustre than that of rubies, is singularly contrasted with the blackness of the soil in which it seems imbedded. The desolate and cloud-piercing summits of the highest hills produce several species, which are the more highly prized from their scarcity, and the difficulties with which they are obtained.[1]

We have alluded to the ease and *economy* with which the study of Entomology may be pursued, more especially when our attention is confined to the species of a district. Of course the collector of foreign insects labours under some disadvantage, from the more multifarious nature of his subjects, their larger size, higher price, and more scattered localities. But the home collector, especially of the Coleoptera, is more favourably situated.[2] The total Entomology of most districts may be amply illustrated within the bounds of a cabinet of a few feet square, and the most ordinary attention and regularity suffice for its preservation. Most districts produce species which are comparatively rare in other quarters, and thus by means of interchanges numerous additions may be made from time to time: so that with a moderate share of assiduity and perseverance, a large collection may be amassed with little or no pecuniary outlay. In these and many other pleasant particulars, on which we need not here dilate, Entomology possesses advantages over all the kindred branches of natural history. We shall now pass to a short exposition of some of the more characteristic features in the structure and functions of insects.

CHAPTER II.

THE EXTERNAL ANATOMY OF INSECTS.

Our knowledge of the manners of these creatures presents us with few general results, and this is scarcely to be wondered at, when we consider with how small a number we have any accurate acquaintance. It may even be doubted whether we are completely informed of the history of any one species within the entire range of Entomology. Of some we know the perfect state, but have never seen the larva; of others the larvæ are well known, but the perfect insect remains in obscurity, so that when we consider the numerous changes which these creatures undergo, from their first hatching to their final metamorphosis, we need scarcely wonder that even the most familiar species present points in their history, which it is by no means easy to unravel.

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[1] The foregoing brief "defence of insects" coincides with that which, since the above was written, has appeared in our *Entomologia Edinensis*.

[2] A glazed frame or drawer, lined with cork, and capable of containing many hundred species, may be made for a few shillings.

It is otherwise however with the classification of insects, which, depending mainly on an attentive examination of external characters, is so far independent alike of anatomical investigation and the study of manners, although these, when ascertained, form of course the truest test by which to appreciate the difference between a natural and an artificial system.

The period is comparatively recent during which the internal structure of insects began to be regarded as a subject of interest. Their external characters were the first to attract attention; and as a communicable knowledge of these was necessary for all the practical purposes of classification, as well as to establish the means of mutual understanding among naturalists, it is well that that branch has been rendered so complete and satisfactory. In former times, whatever facts of interest might have been ascertained, were too often but of slight avail, in consequence of our vague knowledge of the species to which they applied. But the most ordinary attention on the part of the anatomist, to the systematic works of modern times, will now suffice to inform him of the place which his subject occupies in the scale of nature; and hence the importance, not seldom overlooked by the physiologist, of even the minutest external characters, when accurately ascertained and clearly described. It has indeed been stated as a truism, that whoever attempts to deduce the real affinities of the animal kingdom from a consideration of the external characters alone, will in most cases mislead both himself and others.[1] But it must also be admitted, that comparative anatomists have too frequently an idea that nothing is or can be of importance which extends beyond the sphere of their own exertions. They forget that the general form and covering, and, in short, the whole of the external characters, however they may labour under the misfortune of being obvious to a common observer, are just as much a part of an animal's organic constitution, as the nerves, viscera, muscles, blood-vessels, and bones, or whatever else is most mysterious and recondite; and that, in fact, without a precise knowledge of the former, the information conveyed by the latter would be uncertain, or of no avail. The chief advantage of the internal structure is, that it is less liable to variation from the influence of local or accidental circumstances: its chief disadvantage results from the difficulty of its ascertainment, and the contrariety of opinion which exists among physiologists regarding the uses of the organs, even after their conformation has been ascertained. A mere knowledge of external character is perhaps nearly as useful as an acquaintance, however intimate, with anatomical structure, when nothing is either known or sought for respecting the external appearance, as a necessary guide to the higher knowledge of animal instincts and modes of life, the uses of living creatures in the general economy of nature, their exquisite adaptation to the circumstances under which they are placed, their distribution over the earth's surface, and other points of philosophical investigation. The mere anatomist may smile at the mere collector of shells and butterflies; and with just as much propriety may the mere naturalist or virtuoso smile in return at him who, knowing, or supposing that he knows, every convolution of a viscus, or ramification of an artery, is yet unable to recognise, amid the perplexingly multiplied varieties which may be presented to him, the precise animal which has been the subject of so much anxious and careful investigation. But when anatomy and natural history go hand in hand, the obscure labyrinth of nature, so far as human capacity can penetrate, receives its noblest illumination.

Notwithstanding the meritorious labours of Swammerdam, Malpighi, Réaumur, and Lyonnet, who were the first greatly to signalise themselves in the difficult field of insect anatomy; in spite of the more recent and scarcely less successful exertions of Cuvier, Comparetti, Ramdohr, Treviranus, Gaede, Sprengel, Savigny, Marcel de Serres, Geoffroy St Hilaire, Carus, Meckel, Audouin, and Dufour (to make no mention of many others who yet deserve to be held in remembrance),—such is the immense extent and variety of this wonderful class of beings, that we fall infinitely short of possessing any thing like a general or completed knowledge of their structure. In this paucity of well-established facts under which we labour, it would indeed be unphilosophical to attempt the induction of general rules; and all that we shall here attempt shall be to record such observations as seem likely to bear substantially upon the subject, and to have formed an actual advance in our knowledge of the anatomy and physiology of insects.

The study of the interior structure of these creatures does not at first sight hold out the promise of much that is either interesting or useful. The enormous distance which seems to separate all invertebrated animals from man, and even from the lower mammiferous and other vertebrated tribes, has induced the belief that no practical results can ever spring from such a source. But the philosophical observer, who knows how important is frequently the connection between the greatest and the least of things, and how, like the thread of Ariadne, the tracing of a slender chain may lead to unforeseen conclusions of the highest value, will not despise the lights which a better knowledge even of insect anatomy may be one day destined to throw upon some of the many still obscure points in the physiology of man. The observations of M. Dufour and others have already shown us what an admirable simplicity presides in these despised tribes over the exercise of those most important functions, which in red-blooded animals require such a complicated organic structure as to be almost incomprehensible. But as we descend in the scale of nature, we see more clearly the distinction between what is necessary, or merely accessory or superfluous, and thus by degrees we may attain to a knowledge of the essential characters of things.

Even in its more superficial bearings on natural history, the dissection of insects is necessary to ascertain several disputed points regarding the sexual distinctions of species, and to verify our views of the structure of the organs of the mouth, the antennæ, tarsi, and other external parts, on which our establishment of tribes and genera mainly depends. When it is desired to dissect an insect, it ought to be placed on a piece of cork, immersed in pure water; and the various parts, as they float in the liquid, may be fixed in their most appropriate position by means of needles. With a view to prevent deception from any alteration in the relative position of the internal organs, it is desirable to fix the insect in its natural horizontal posture, and to commence the dissection from the dorsal region downwards.

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[1] Wilson's *Illustrations of Zoology*, vol. i. pref. p. 4.

The following observations on the dissection of the minuter animals may be of service to the student. "The first thing that I have to observe is, that all dissections of small and soft objects, *e. g.* worms, zoophytes, insects, mollusca, &c. where it is desirable to obtain even tolerably accurate results, should be performed *under water*, by which the parts are kept floating and separated from each other, and consequently present themselves more distinctly. A very simple contrivance for investigations of this kind may be prepared in the following manner: A mass of tough wax (not too soft) is to be laid upon one or more porcelain saucers or capsules of different sizes, which are then to be put in a warm place until the wax melts so as to cover the surface evenly to the depth of a half or a third of an inch. If the object to be examined be laid upon this surface, it may be fixed by needles in any position that is wished; and, when covered with clear water, developed and dissected by means of suitable instruments. Of these, the best are very delicate forceps; pointed, well made, sharp-cutting scissars; and small knives like cataract needles, some round, others with cutting edges, and fixed in slender wooden handles. For separating parts I have also employed small horn probes and fine brushes; whilst for examining them a good magnifying glass is frequently indispensable. If it is wished to preserve a preparation thus made, wax coloured at pleasure, as for the purpose of injections, is to be formed into little tablets about a quarter of an inch thick; one of them is then to be placed upon the saucer or capsule containing the preparation; the latter may then be transferred to it, arranged suitably upon it, fixed there by means of short needles, and both together placed in alcohol. Nor must I forget to mention, that the examination of very delicate organizations may frequently be conducted with greater facility and accuracy, if the object be previously allowed to remain some time in spirit, and thereby to become harder and contracted. This applies particularly to the dissection of nervous organs, and to the examination of very small embryos, of mollusca, and worms. There are various ways of destroying worms, insects, &c. for the purpose of dissecting, without injuring their organization. Mollusca, snails for example, as Swammerdam has remarked, are to be allowed to die in water, because by that means their body swells, and all the parts become more distinctly visible; they may afterwards be kept in spirit (though not too long) for dissection. Worms, the larger zoophytes (for the smaller must be examined whilst alive), caterpillars, &c. are best destroyed by means of spirit; insects, on the contrary, by being dipped rapidly in boiling water, or in oil of turpentine."[1]

SECT. I.—THE EXTERNAL COVERING OF INSECTS.

Our knowledge of the structure and anatomy of this class may be said to be still in its infancy; for although many important facts have been legitimately generalized, we are still in ignorance of the formation of a thousand species for every one which has been examined. As the harder parts of insects, to which the muscles are attached, are superficial, the class has been described as bearing their skeletons externally; and a transcendental anatomy has not scrupled to determine the exact analogy which each portion of their covering bears to the bony frame-work of the vertebrated tribes. This comparison has been instituted by M. Geoffroy St Hilaire, an eminent physiological naturalist of France, who maintains, with many of his countrymen, that all animals are vertebrated. The doctrine, whatever may be its other merits, is not entitled to the credit of novelty, as an English writer of the name of Willis had, so far back as the year 1692, published his opinion that the external envelope of the body of insects represented the internal articulated column of the vertebrated tribes. M. de Blainville, on the other hand, regards the corneous covering of insects rather as analogous to the skin or cutaneous system of the higher classes.

The hardness of the calcareous or horny envelope of the greater number of insects is owing, in Latreille's opinion, to the consistence of the excretion interposed between the dermis and the epidermis, or what is termed in man the *mucous tissue*. This excretion also contains the brilliant and varied colours which add so greatly to the beauty of the class.[2] According to M. Odier, who has attentively examined the composition of the harder parts of insects, the substance of this envelope is of a peculiar nature. He has named it *chitine*. He observes that the phosphate of lime forms the great proportion of all the salts contained in the teguments of insects, while that ingredient is but trifling in the covering of the Crustacea, although the latter abounds in the carbonate, which is not found in the other class.[3] The facts stated by him militate against the analogies attempted to be established on the subject; and the observations of M. Straus go far to demonstrate that those teguments do not form a true skeleton, but really represent the skin of the vertebrated classes. When we use the word skeleton, then, in relation to insects, the reader will understand its application merely to the external covering.

On analysing the elytra of the cockchafer, M. Odier ascertained the existence, 1*st*, of albumen; 2*d*, of an extractive matter, soluble in water; 3*d*, of a brown-coloured animal substance, soluble in potass and insoluble in alcohol; 4*th*, of a coloured oil, soluble in alcohol; 5*th*, of three salts, viz. subcarbonate of potass, phosphate of lime, and phosphate of iron; 6*th*, of a peculiar substance which constitutes a fourth part in weight of the elytron. Albumen is so generally distributed among the animal organs that its presence was to be expected. But the oil is deserving of further experimental observation. Robiquet found it of a green colour in cantharides; while, according to Odier, it is brown in the cockchafer, and red in a species of crioceris. Now as each of these insects is itself of a corresponding hue, it is natural to suppose that the oil is the colouring matter. The peculiar substance which forms so large a proportion of the elytra is named *chitine* by M. Odier. If we plunge a coleopterous insect into a solution of potassium, and keep up a pretty high temperature, we shall observe that the so-called skeleton neither dissolves nor changes its form; it merely becomes discoloured during the operation, while all the viscera and interior muscles disappear; and whatever remains of the insect is *chitine*. This substance exists in the whole of the envelope, and is also found to occur in the more solid covering of the Crustacea.

If however we compare the preceding results with those obtained by M. Chevreul in the course of his experiments on crustaceous animals, we shall perceive some remarkable distinctions in the constitution of their harder parts. The presence of subcarbonate of potass is a striking character among insects. It does not occur in the class Crustacea. The phosphate of lime, a sparing ingredient among the latter, forms a preponderating part of the salts in the envelope of insects, while the carbonate of lime is absent, although it forms the base of the carapace or covering of crabs and lobsters. It has been stated as a regulating law in animal chemistry, that the bones of the higher orders have more of the phosphate and less of the carbonate of lime in their composition, while the proportions were reversed among the inferior tribes. But the observations of M. Odier show the inadequacy of chemical character to serve as a basis on which to found our analogies of organization; for if strictly applied to insects, that class must be removed from the place which they now occupy in our system, and be combined with others of a higher nature, with which in truth they have no connection.

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[1] Carus's *Introduction to Comparative Anatomy*, translated by Gore, vol. ii. p. 389.

[2] *Règne Animal*, t. iv. p. 2.

[3] *Mem. de la Soc. d'Hist. Nat.* t. i. p. 29.

The harder and more solid parts of insects are certainly to them what the internal skeleton is to the vertebrated tribes. They form the support and frame-work of the body. It is on this account that the term *skeleton*, though not strictly applicable, has been used, both in ancient and modern times, to designate the *corneous external system* of these creatures. This comparatively solid system is itself formed by the union of many parts, which however have received no general name; so that, while in discussing the vertebrated tribes we merely say that their skeleton is formed of bone, all that we advance in regard to insects is, that it is composed of pieces. In the higher tribes each individual bone is well known by its own distinctive name; but the insect tribes in that respect have been but obscurely defined. Guided by the light of human anatomy, observers have sought to discover in insects all those parts to which they could apply previously established names; but analogies based upon mere appearance are incapable of great or useful extension; and insects would certainly have been better known had they been studied in the first place individually, and no far-fetched comparisons instituted till after a more ample knowledge of actual organization. But instead of this, the best determined functions of the superior animals have been assumed as points of departure, and all the parts of insects which *seemed* to fulfil the same purposes have been determinately regarded as analogous. Now it is quite admissible to say, that in insects, as among the vertebrated tribes, there is progression, vision, manducation, &c. because these are the attributes, more or less general, of all living beings; but it has not always been demonstrated that particular and more special functions are always performed by the same or apparently corresponding parts. M. Dufour, however, has announced the following results in relation to the articulated animals themselves: 1*st*, that the skeleton of the Crustacea and Arachnides (two important classes already described in this work) does not differ from that of insects except by the mode of growth of the rings of which it is composed; 2*d*, that those two classes of animals and insects themselves do not differ among each other, but by the greater or less extent in the development of the parts of which they are composed.

The same may be asserted in regard to the disparities observable between the different conditions of insects in the larva, the chrysalis, and the perfect state. The various forms under which the same species is exhibited, and the singular and sometimes sudden transformations to which it is subjected, are found to result, when analysed, from the growth of parts. This has been demonstrated by the writings of Swammerdam and other modern writers on the anatomy of caterpillars, as well as by the beautiful and more recent observations of Savigny on the mouths of Lepidoptera in the perfect state, compared with the same parts in their earliest condition.[1] The observation is particularly applicable to the solid parts of insects. In the larva each segment exists under a nearly uniform development, while in the perfect state several of these segments have acquired a prodigious increase. This is the cause of the vast difference in their exterior envelope at different periods of their existence. The nymph or chrysalis is in the intermediate condition, and is formed, like the larva, of simple rings, which, however, no longer exhibit an equal degree of uniformity. But the perfect insect is the final term of transformation. Considered in a general way, its covering does not essentially differ from that of the larva; but the three segments next the head have acquired a great increase of bulk, to enable them to support the appendages of legs and wings, which were merely rudimentary, or scarcely existent, in its first condition; and the distinction of head, thorax, and abdomen becoming strongly visible, the entire aspect of the insect has undergone a change.

It is highly interesting to observe the influence which the decrease or development of one portion of structure exercises upon another; in other words, the constant and intimate relation of the proportion of parts. The maximum of increase in the metathorax is always in relation to the rudimentary state of the mesothorax, while, on the contrary, the development of the latter produces or accompanies the decrease of the former. Thus also the parts of the mouth, as demonstrated by M. Savigny, are sometimes free, and capable of varied movement, for the purposes of mastication; while in several tribes they are brought close together, lengthened, and as it were amalgamated in the form of trunk or sucker; and so the segments of the thorax, in the different orders, more or less disunited among themselves, support the wings, the balancers, the elytra, according to the various kinds. From these and similar considerations have been deduced the conclusion that the increase of one portion exercises over the neighbouring portions a peculiar influence, which explains whatever differences may be remarked in the individuals of each order, family, and genus. And this general consequence, which results from numerous observations, necessarily includes and accounts for that incoherent series of anomalies so puzzling to the superficial inquirer, but which are only regarded as such, because the labourers in the field of anatomy have but seldom taken into their consideration the totality of the articulated animals, and have more seldom still thought fit to occupy themselves in a careful comparative analysis of the parts which enter into the composition of the external skeleton of these despised tribes.

We shall here briefly consider the essential characters of the so-called skeleton among the articulated tribes. It is composed of segments, which are themselves formed by a determinate number of pieces; but their most obvious character is, that they are provided with a pair of feet, and with two openings to the respiratory organs. But along with such segments as present these parts, we may usually observe many others which are not so provided, or at least in which the feet are wanting; and they may either differ in their size and proportions, or closely resemble each other in those respects. In the latter case, the most simple form is exhibited; and if we ascertain the composition of a single segment, and their amount, we have a knowledge of the entire animal. This simplicity of form, however, is not often observable; for it more frequently happens that the same individual presents great disparity in the size and composition of its segments, and in the appendages with which they are furnished.

The Scolopendræ (belonging to the class MYRIAPODA) ex-

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[1] *Mémoires sur les Animaux sans Vertèbres.*

hibit, according to M. Dufour, one of the most simple forms of the articulated classes, in as far as they present the greatest uniformity of character in the parts of which they are composed. Even in them, however, we may observe, at the anterior portion, some pairs of feet, which are rudimentary, and crowded together towards the head; so that it would be possible to figure an animal still more uniformly composed, by supposing that the feet thus thrown together had been developed uniformly with the appendages of the ensuing segments. We should then have had to recognise merely a head, and a certain number of rings, all of a like nature. But it might be possible still further to reduce and simplify the proposition, by regarding the head itself as an assemblage or union of segments, bearing appendages merely analogous to the feet. Thus, to realize the supposition of a skeleton uniformly constructed throughout all its parts, nothing more would be necessary than to give to the segments of the head a development equal to that of the others, and to restore to its appendages (the feet) their essential usage, that of locomotion, instead of the secondary usage to which they had been subjected. This view has been presented in order to exhibit what has been regarded as the fundamental plan of insect formation; for it is in truth the corresponding or unequal increase of the segments, the union or division of the pieces of which they are composed, the maximum of development in some, the rudimentary condition of others, that form the agreements or differences of character in the entire series of articulated animals.[1] If the development is uniform, or nearly so, in each segment, we have the condition of the *Annelides*, of *worms*, and of the *larvæ* of insects. If, on the contrary, this equilibrium is destroyed, and the maximum of increase takes place in the first, second, and third segments ensuing the head, we have the form and character of a *perfect insect*; if the change is still greater, we reach the *Arachnides*; if greater still, the *decapodous Crustacea*.

The importance of studying the skeleton of insects is greater than even among the higher classes, because, being essential, it forms a genuine basis, and being at the same time external, it offers to the eye of the zoologist a ready mode of determination.

While engaged in the consideration of the various organs of insects, a numerous list of disparities in structure might no doubt be collected, and the term *anomaly*, according to its frequent but by no means philosophical application, brought into constant use. That fatal word, however, has been too often substituted in place of an explicit interpretation of phenomena not in any way difficult of solution, certain general principles being kept in view. Of these, one of the most importance is, that all the differences exhibited by insects, and all the so-called anomalous organs which they present, are the result of a greater or less development of certain parts existing generally throughout the entire class.[2] The contrariety of opinion among naturalists regarding the existence or proportion of certain parts of structure, has arisen partly from a discordance in the use of terms, and partly from the organs themselves not being submitted to a careful analytical investigation. It is thus, for example, that the names of *sternum* and *scutellum*, in place of being bestowed on portions of which the contours have been precisely determined, have only been applied when these portions happened to exhibit certain accidental and conventional characters. By this means we read in almost every page of classification, that one insect possesses a scutellum and that another does not; or that a particular genus is characterized by its existence, and another by its absence; while the fact is, that these parts exist in all insects, although the names in their usual application have been bestowed only upon peculiar and not very important variations in the *form*.

SECT. II.—THE EXTERNAL CHARACTERS OF THE PRINCIPAL SEGMENTS OF AN INSECT'S BODY, VIZ. THE HEAD, THORAX, AND ABDOMEN.

The form of the external covering of insects, even of the same species, differs greatly according to the existing condition of the individual. The segments of which the bodies of larvæ are composed are generally of a uniform size when compared with each other, and the singular phenomena presented by metamorphosis consist chiefly in the greater development assumed by certain segments than by others. The nymph (called chrysalis among the Lepidoptera) exhibits the intermediate or transitionary state. Its segments are unequally developed, and this inequality is greatly increased on the assumption of the final state, in which certain segments are prodigiously enlarged, while others suffer a corresponding diminution. In the imago, or complete condition, the three segments next the head undergo the most notable alteration; for, besides their increase of bulk, they become furnished with wings and articulated legs, which had previously existed in a very rudimentary condition. In that state also the relative proportions of the segments are so changed that the identity of several becomes difficult to recognise, and the most obvious divisions henceforth consist of *head*, *thorax*, and *abdomen*. These parts are severally characterized by peculiar attributes, the nature of which we shall now endeavour to explain.

The *head* is by far the most complicated portion, and it is necessary that its structure should be well understood, as it furnishes the most important characters on which modern genera are founded or made known. The parts most deserving of attention are the *mouth*, *antennæ*, and *eyes*.

The organs of the mouth present in their different combinations a great variety of form among the articulated classes. In relation to all such animals as are provided with a head, more particularly the vertebrated tribes, the term mouth is never of ambiguous application, but refers to those parts which are placed exteriorly at the entrance of the intestinal canal, and effect the process of mastication; but in regard to the acephalous or nearly headless tribes, such as annelides, worms, and the radiated animals, its application is less definite and precise. Among the great series of living beings included by Linnæus in the class of insects, all of which are furnished with a head, the parts of the mouth are no longer doubtful. It has been remarked, however, that the sucker of the larvæ in the last family of the dipterous order being entirely interior when not in use, presents a singular approximation in that particular to the intestinal worms.

It will be readily conceived that the mouth of insects must be adapted to the particular manners of life peculiar to each natural group, and must therefore vary in accordance with their instinctive habits. It was thus that even the earliest naturalists perceived and expressed the distinction between insects provided with teeth or cutting jaws, and those furnished with trunks or suckers. The use of the microscope in modern times, and the deep desire which prevailed towards the conclusion of the seventeenth and commencement of the eighteenth centuries, to illustrate the mysteries of animal organization, produced much more detailed and exact accounts of the parts of the mouth in insects than were previously possessed. The works of Leeuwen-

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[1] *Ann. des Sciences Nat.* t. i. p. 115.

[2] *Ibid.* p. 102.

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hoeck, Swammerdam, and Réaumur are mines of information; while Scopoli and Degeer still further generalized the observations of these illustrious naturalists. Scopoli, we believe, was the first to apply the knowledge of these parts in characterizing the genera of the hymenopterous and dipterous orders; but it is to a celebrated disciple of Linnæus, John Christian Fabricius, that we owe the first general theory of the parts of manducation, and its application to entomology in general.

The alimentary substances sought for by insects are either comparatively hard and solid, or of a more soft and fluid nature. Thence we find upon examination numerous tribes of insects provided with a mouth so constructed as to tear and masticate the substances on which it is designed to act; while many others are characterized by a tube-like mouth, or one resembling a delicate tongue extended when in action, and spirally rolled upon itself when in repose. Hence the great primary distinctions among the orders of insects, and their recognised division into masticators (*mandibulata*) and suckers (*haustellata*), the former living on solid substances, the latter on such as are fluid. Whatever may be the structure of the mouth in insects, it is to one or other of those types of form that each must be referred. We are indebted to the beautiful researches of Savigny (1814) for the first accurate analysis and elucidation of these parts, and of their relationship throughout the articulated tribes. Latreille, however, had previously instituted a slighter comparison between the mouths of the suctorial and mandibulated tribes, as Lamarck has admitted in his report on Savigny's work.

Savigny divides insects formerly so named into two groups, the *hexapodes*, or such as have six feet, and the *apiropodes*, or such as possess a greater number. The mouth of the latter forms two proper types distinct from those of the former; but it is with the polymorphous hexapodes, or such as undergo transformations, that is, insects properly so called, that we are now concerned. We shall first consider the parts of the mouth in the masticating tribes. They are essentially as follows: The *labrum*, the *mandibles*, the *maxillæ*, the *palpi*, the *labium*, and the *mentum*, the two latter, according to the views of different observers, sometimes passing under one and the same name. The reader may here consult Plate CCXX. fig. 1, *a, b, c, d.*[1]

The *labrum* or upper lip (fig. 1, *a*) is a flattened somewhat deflexed portion, consisting of a single piece,[2] placed on the upper side of or above the mouth, and capable of moving upwards and downwards, or vertically. It is variable in form, but is usually somewhat square, often wider than long, and frequently notched or bifid. It is of a horny consistence, sometimes coriaceous, or even approaching to what may be named membranous in certain tribes, and is attached to the anterior portion of the head by a very short articulation.

The mandibles or upper jaws (*mandibulæ*, fig. 1, *bb*) are two strong horny pieces, generally of a triangular form, more or less curved, convex externally, concave on their inner surfaces, and frequently toothed or serrated on their interior edge. They are placed on each side of the mouth by insertion on the sides of the head, immediately beneath the labrum or upper lip, which usually covers their base. They are each composed of a single piece of a hard consistence, and may be said to correspond to the jaws of the vertebrated tribes, the process of mastication being principally performed by them. They differ, however, in this respect, that their motion, instead of being vertical, is horizontal, or from within outwards, and *vice versa*. They vary greatly both in their actual size and relative dimensions, being small and slender in the glow-worm (*Lampyris*), and very large, projecting, and antler-like in the stag beetle (*Lucanus cervus*), the species which we have selected for our engraved illustration. These internal surfaces are frequently parallel, but their dentations are not always the same in each, the projections of the one being however frequently so arranged as to enter the concavities of the other in order to admit of their closer union. But this is not seldom prevented by the curvature of the tips; and in several instances, where the mouth is wide, and the mandibles rather remote from each other at the base, the blades cross each other a little beyond the centre. The dentations of the mandibles, though sometimes called teeth, are merely projecting parts, although in the orthopterous tribes a coriaceous lamina seems in some respect to distinguish them from the body of the mandible to which they are attached, thus exhibiting an approach to that mode of fixture called *gomphosis*, in which one bone is fixed within another, as in the teeth of the higher tribes. The mandibles are more variable in their forms than the maxillæ, and may occasionally be observed to differ (as in the genus *Lucanus*) even in the sexes of the same species.

Immediately beneath the mandibles are situated the *maxillæ* or under jaws (fig. 1, *cc*), which are likewise placed on each side of the mouth, and take their origin from the inferior and internal part of that cavity, near the origin of the under lip. Like that of the preceding parts, their action is horizontal, but their texture is less rigid, approaching to membranous, their colour usually paler, and their internal edges toothed, or finely fringed with hairs. The different portions of the maxillæ have received different names, such as the *cardo* or hinge, the *stipes* or stalk, and the *lobus* or lobe (one or more) which forms the terminal portion. The last named is the most important portion, as it acts upon the food when preparing for deglutition, and when armed with teeth its substance is as hard as that of the mandibles. "This part," says Mr Kirby, "is either simple, consisting only of *one* lobe, as you will find to be the case with the *Hymenoptera*, *Dynastidæ*, *Nemognatha*, and several other beetles; or it is compound, consisting of *two* lobes. In the former case, the lobe is sometimes very long, as in the bee tribes, and at others very short, as in hister, &c. The bilobed maxillæ present several different types of form. Nearest to those with one lobe are those whose lower lobe is attached longitudinally to the inner side of the stalk of the organ, above which it scarcely rises. Of this description is the maxilla in the common dung beetle (*Geotrupes stercorarius*), and rove beetle (*Staphylinus olens*). Another kind of formation is where the lower lobe is only a little shorter than the upper; this occurs in a kind of chafer (*Macraspis tetradactyla*, Macleay). A third is where the upper lobe covers the lower as a shield; as you will find in the *Orthoptera* order, and the *Libellulina*, and almost in *Meloe*. A fourth form is where the upper lobe somewhat resembles the galeate maxilla just named, but consists of two joints. This exists in *Staphylinidæ*, &c. The last kind I shall notice is when the upper lobe not only consists of two joints, but is cylindrical, and assumes the aspect of a feeler or palpus. This is the common character of almost all the predaceous beetles (*Entomophagi*, Latr.)."[3] This lobe, which has been usually regarded as an additional palpus or feeler, is strictly analogous, in Mr Kirby's opinion, to the upper lobe in other insects, and he thinks it ought rather to be called a palpiform lobe than a *palpus*. When there are two lobes, the upper one is most commonly the longer; but in many species of the tribe last alluded to, the lower equals or even exceeds the upper in length.[1]

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[1] *a* is the labrum, surmounted by its broad nasus; *b* the mandibulæ; *c* the maxillæ, with their jointed palpi; *d* the bifid labium, with its two palpi and broad basal portion or mentum.

[2] In the female of a small bee of the genus *Halictus* it is said to be furnished with a slender appendage.

[3] *Introduc. to Entom.* vol. iv. p. 442.

Most of the predaceous beetles have the inner lobe of the maxillæ armed with a terminal claw, which, among the Cicindelidæ, is articulated and moveable, but fixed in the other carabideous kinds. The maxillæ are chiefly serviceable in holding the food, and preventing its falling from the mouth during the action of the mandibles, although in certain cases they no doubt also act their part in comminution. They are more fixed in their forms than the mandibles, and are of more essential service to the naturalist for the purposes of classification. Fabricius, indeed, has deduced the principal diagnostic of ten out of the thirteen orders (or classes, as he terms them), of which his system is composed, from these important parts.

We shall now briefly notice certain appendages of the maxillæ, the existence of which forms another distinction between them and the mandibles or upper jaws, which are never so provided. Towards the middle of the outer edge of the maxillæ are attached two slender articulated filiform processes, known under the name of palpi (see the figure above referred to); the longer pair being the external, the others the internal palpi. Both are called *maxillary*, to distinguish them from the *labial* palpi, afterwards mentioned. According to the view expressed by Mr Kirby in the preceding quotation, the reader will perceive that each maxilla may be regarded as properly possessing only one palpus, although in certain tribes the upper lobe being jointed and *palpiform*, has occasioned its being regarded as one of these organs. The palpi are distinctly articulated, or composed of several jointed parts, and are capable of rapid and extended motion. They derive their name from a Greek word, which signifies to feel, and are supposed to constitute one of the principal organs of touch. Their uses, however, in the insect economy have been variously interpreted. Bonsdorf regarded them as the organs of smell; while Knock, agreeing in that opinion so far as regards the *maxillary* palpi, conceives that those of the *labium* exercise the faculty of *taste*. Cuvier and Kirby favour touch as their true function, and this view is confirmed by the constant use which numerous species make of these organs while walking, by applying them perpetually to the surface of whatever objects they pass over. That they perform that function is rendered extremely probable by their structure, which is beautifully adapted, by its peculiar pliancy, to the examination of the substances with which they come in contact. They are in some respects analogous to the articulated extremities which form the principal seat of the sense of touch in vertebrated animals. It has also been noticed that several aquatic beetles, while swimming, bend back their antennæ, and stretch forward their palpi, as if to explore their way through the ambiguous and weedy waters. As accessory to the maxillæ, they are no doubt also employed in the selection of the most suitable alimentary portions of whatever substances have been previously seized upon by the more powerful parts of the mouth. In many insects there is only a single palpus to each of the maxillæ.

As the mouth is covered above by the *labrum*, or upper lip, so it is closed below by the under lip, or *labium* (fig. 1, *d*). The latter differs in its structure from the labrum, being more complex than that organ, and composed as it were of two portions joined together. It varies in its form, is usually notched in front, and frequently furnished with a triangular tooth in the centre, which is sometimes bifid. Mr Kirby defines the labium as a moveable organ, often biarticulate, which, terminating the surface anteriorly, covers the mouth from beneath, and is situate between the maxillæ. It includes the mentum and labial palpi. The more uncovered portion of the labium, or that which projects from the basal portion, is now named *languette* or *ligula* by Latreille, in consonance with the nomenclature of Fabricius. The *mentum*, or chin, is the lower joint of the labium when the latter is jointed; in other cases its base.

Some contrariety of opinion seems to exist in the nomenclature of these parts. Mr Macleay bestows the name of *mentum* on the middle piece of the lower apparatus of the mouth. Its anterior portion, to which the palpi are so frequently attached, he calls the *labium*, while the basal part of the mentum is designated the *stipes*. In this view the labium of Macleay corresponds to the *ligula*, or rather tongue, of Kirby, while the mentum of the latter is analogous to the stipes of the former; for it appears that the term mentum is only applied by the author of the *Introduction to Entomology* to the lower division of the labium, when that organ (as in *Hydrous piceus*) appears to consist of two joints or pieces. When there is no apparent division, or the only separation consists in a transverse elevated line (as in some lamellicorn beetles), or an obtuse angle formed by the meeting of the two parts, then the entire piece (the *mentum* merging in it) is regarded by Mr Kirby as the *labium*.

Among the greater proportion of masticating insects there is placed anteriorly at each side of the ligula a small supporting piece or article, which takes its rise a little above the pharynx, and is terminated by a projecting appendage. These parts were named *paraglossæ* by Illiger; and M. Latreille regards them as the true representatives of the tongue of the higher tribes. The labial palpi (Fig. 1, *d*), are inserted on each side of the ligula, and are usually longer than the internal and shorter than the external maxillary palpi. These palpi have never more than four articulations, in which they also differ from the external maxillary, which range from four to six. They are called labial palpi, because in many cases they derive their origin from the labium strictly so called; but in reference to Mr Kirby's nomenclature of the parts, they might with equal propriety be denominated lingual palpi, since they not unfrequently emerge from what that excellent observer considers as the tongue. Among the predaceous Coleoptera, indeed, their source seems common to both these parts, as their base on its upper side is attached to the labium, on its under to the ligula or tongue.

In some insects, such as the Orthoptera and dragon-flies, the membranous portion with which the anterior or internal face of the ligula is furnished, is thick and dilated near the centre, in the form of a little tongue, and is often divided near the middle by a groove. This portion, in the opinion of Latreille, probably occupies the place of the *paraglossæ*; for these latter, in the instances referred to, are wanting, or not to be recognised.

These are the principal parts of the mouth among the masticating insects. At the anterior root of the ligula, and a little lower than the middle of the interior space which intervenes between the mandibles, is placed the *pharynx*. In many Hymenoptera this orifice of the œsophagus opens and shuts by means of an appendage, previously noticed by Réaumur in humble bees, and taken by Latreille for the labrum, in his observations on the structure of wasps. Savigny has since paid particular attention to it, and has named it the *epipharynx* or *epiglossa*. Latreille conceives it would be more simple to call it the *sublabrum*, because it is inserted beneath the anterior and superior margin of the head, immediately after the origin of the labrum. It is formed of two flattened portions, entirely or in great part membranous, applied the one upon the other, and of a triangular form. The upper portion is the most advanced. This epipharynx, instead of being peculiar, as some have supposed, to the Hymenoptera, may be safely regarded as existing in the other masticating insects, particularly the Coleoptera, among which it seems represented under a modified form of structure by the membrane which clothes the corresponding portion of the head.

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[1] *Introduc. to Entom.* vol. iv. p. 442.

Although the hymenopterous tribes differ from the other mandibulated orders, by the prolongation of the maxillæ and labium, and the valvular aspect of the former, yet the parts of the mouth do not present any essential distinction. A remarkable characteristic of these orders, however, consists, as Savigny informs us, in the absence of the mentum properly so called. They also exhibit this disagreement from the other masticators, in as far as their maxillæ embracing longitudinally the sides of the labium, these parts unite together so as to form a tubular body or trunk (*promuscis*), serving for suction. As their aliments consist of softish substances, or of nectarous juices, which, passing between the maxillæ and the labium, by means of the successive pressure of the former parts upon the latter, eventually arrive at the pharynx, they may in truth be regarded as semi-suctorial. Even the Rhinchophori among the Coleoptera, and the Panorpati in the neuropterous order, are furnished with an apparent trunk or prolongation of the muzzle (*prorostrum*); but that peculiarity is nothing more than an extension of the anterior portion of the head; and the organs of manducation, placed at its extremity, though of diminished size, in no way differ in structure from those of the other groups of their respective orders. We may add, that the labium or lower lip in the hymenopterous tribes is generally moveable at its base, as may be observed in the corresponding tribes of the suctorial insects.

In the suctorial or haustellated orders, properly so called, the organs of the mouth appear at first sight to differ entirely from those above described. The parts which are regarded as analogous to the maxillæ, and frequently even those which represent the mandibles, are fixed and immoveable, either entirely so, or towards their base, and (in regard to the maxillæ) as far as the origin of the palpi. When the terminal portion is moveable, it is long, narrow, linear, sometimes in the form of a thread or bristle, sometimes resembling a dart or lancet, and fitted for piercing. The pharynx is the central point around which these portions arrange themselves after the tubular form. Sometimes the lower lip, united with the inferior portion of the maxillæ, and fixed like it, closes the cavity of the mouth, and the maxillæ then constitute a kind of spiral tongue. In other cases it is greatly prolonged, and assumes the form of an articulated tube, or of an elbowed trunk, usually terminated by two lips susceptible of dilatation. In either of the latter states it serves as a sheath to certain portions of a scaly structure and piercing nature, in the form of a bristle or lancet, and representing the other parts of the mouth. Sometimes this sheath (as in *Pulex*) is bivalvular, but it more frequently consists of a single piece laterally folded so as to form a tube open on the upper surface. In this longitudinal canal or gutter, the preceding parts are lodged, and compose by their general union the sucker, or *haustellum*. In some instances the palpi have disappeared, in others only two are visible. When there are four of these parts, two of them, the maxillary, are extremely small, or almost imperceptible. Sometimes, as among the pupiparous Diptera, the lower lip is either nonexistent or rudimentary, and the palpi become the sheath of the sucker. Though we make frequent use of the latter term, it may be remembered that its application is not strictly correct, as it is not by suction, or the production of a vacuum, that the alimentary juices mount towards the pharynx, but rather by the continuous pressure of the parts upon each other.

Of all the suctorial or haustellated tribes the Lepidoptera are those which differ least from the type of the mandibulated orders in the structure of the mouth,—on which account they have been made to follow in a supposed natural sequence the hymenopterous insects.[1] Their mouth seems to consist of a labrum and of two extremely small mandibles; of a trunk spirally rolled, improperly regarded as a tongue, and presenting interiorly and throughout its entire length three canals, of which, however, the central alone serves for the influx of the alimentary juices, and formed of two linear or filiform bodies, surrounding the pharynx at their origin immediately beneath the labrum. They represent, under peculiar forms and proportions, the terminal parts of the maxillæ, united, hollowed into deep gutters on their internal side, and bearing each a palpus, usually very small and tuberculiform. There is also a labium or lower lip, of a nearly triangular form, immoveable, united, as formerly mentioned, to the inferior part of the maxillæ, which supports the filiform or trunk-like portion, and bearing two triarticulate palpi, covered with scales or hairs, and placed on each side of the trunk, for which they form a kind of sheath. The intermediate canal of the trunk is produced, according to the detailed description given by Réaumur, by the union of the gutters of the internal face of the filiform or extended portions.

The sucker of the hemipterous tribes received from Fabricius the name of *rostrum*, a term translated beak (*bec*) by Olivier and other entomologists of France. A blade more or less linear, coriaceous, divided into three or four articulations, rolled up at the edges so as to form a conical or cylindrical tube, always directed inferiorly while inactive, and presenting along the centre of its upper or anterior surface a kind of canal produced by the opening left between the rolled-up margins,—a sucker composed of four slender, capillary, corneous, flexible, and elastic threads, disposed in pairs, but combined together, with the two inferior portions united in one at a short distance from their origin,—a small piece in the form of a triangular ligula, usually toothed at the extremity, rather coriaceous or almost membranous than of a scaly texture, and covering from behind or from the sides of the tubular body the base of the sucker, and inclosed along with it in the groove of the general sheath,—another piece of the same consistence with the preceding, corresponding by its insertion, and the position which it occupies, to the labrum or upper lip, covering from above the base of the sucker, most frequently itself

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[1] See Plate CCXX. Fig. 5 exhibits the structure of the mouth in *Papilio Machaon*; *a* the head viewed in front, exhibiting the round eyes, one turn of the spiral proboscis, with the pilose labial palpi on each side; *b* shows the tubular spiral maxillæ (which by their union form the proboscis), with the vestiges of palpi at their base; the circular apertures on each side at the bottom of the figure indicate the insertion of the labial palpi; *c* represents the cleft labium and the two palpi, the left one being deprived of its scales to show the articulations; *d* is the minute labrum, with the mandibles on each side of it, ciliated on their internal edge. Fig. 8 exhibits the mouth of another lepidopterous insect, the *Lyndia cannarum* of Savigny; *a* the eyes, scaly spiral proboscis, and the four palpi; *b* one of the maxillæ, with its palpus; *c* the labium and palpus; *d* the labrum and mandibulæ.

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likewise inclosed in the sheath, and of a more or less elongated triangular form,—these are the parts which enter into the composition of the beak-like mouth or rostrum of the hemipterous tribes.[1] The single superior portion which Latreille regards as the analogue of the labrum, appears to cover, at least among the Cicadæ, the base of another more elongated and pointed portion, which has been viewed as corresponding to the epipharynx.[2] The other single and opposing portion, protecting from behind the origin of the sucker, and placed immediately behind the pharynx, represents, according to Savigny, the tongue or hypopharynx. The two superior filaments of the sucker, or those which are exterior, replace, or rather represent, the mandibles, while the two others may be regarded as maxillæ. Finally, the tubular sheath assimilates to the labium or lower lip, even in regard to its articulations. Sometimes the sheath is bifid, as in *Thrips;* sometimes it is divided into two plates, as in *Pulex*. The first of these genera is stated by Latreille to be the only one in which he has discovered palpi. He thinks that the parts taken for such by Savigny in *Nepa Neptunia* (see Plate CCXX. fig. 6, as described in the preceding note), are more probably the rudiments of an articulation of the sheath. Germar indeed admits four palpi as characteristic of a new hemipterous genus of the family of Cicadariæ, named *Cobax;* but Kirby, who about the same period published an account of another generic group under the title of *Otiocerus*, and which offers analogous parts, does not regard these as palpi, but as simple appendages accompanying the antennæ.[3]

In the dipterous order, such as gnats and common flies, the mouth exhibits a great resemblance to that of the preceding tribes.[4] The union of the different parts forms what is usually in that order called the trunk or *proboscis.* We can here also distinguish the component parts of sheath and sucker. The former in dipterous insects is divisible into three principal portions; 1*st*, the *support*, distinguished from the following by an angular elbow, and frequently by a small geniculated article; 2*dly*, the *stalk;* 3*dly*, the summit, formed by two lips, sometimes membranous, large, vesicular, dilatable, striated, exhibiting through the microscope a great number of tracheal ramifications; sometimes coriaceous, and either small and slightly distinct from the stalk, or slender, elongated, and forming a more obvious article, almost as long as the preceding division (as in genus *Myopa*). The support is remarkable in this, that it results from the prolongation of the cutaneous membrane of the anterior and superior portion of the head, or the epistoma, united with the parts representing the labrum, to the mandibles, the maxillæ, and the inferior portion of the labium, as far as the mentum inclusive. This character particularly distinguishes the present tribes from those of the hemipterous order. In other respects the sheath may be said to be constructed on the same plan. The centre of the superior face of the stalk also presents a groove or gutter for the reception of the sucker. The number of pieces in the sucker varies according to an arithmetical progression of three terms, of which the difference is always two,—2, 4, 6; but in all cases there are always two portions which are not paired, the one superior, representing the labrum; the other inferior, placed behind the pharynx, and the analogue of the tongue or hypopharynx. Among the Diptera, as well as in the suctorial tribe (*Pulex*), the latter portion is always scaly and piercing, and contributes, in common with the others, to the purposes of nutrition. It is otherwise with the Hemiptera, and this distinction forms a new character of separation between that order and the insects now under consideration. The parts representing the maxillæ always exist, and are frequently accompanied each by a palpus; but these maxillæ are soldered to the support, and are indistinct, except where their apical portion becomes moveable and elongated, and presents the form of a seta or horny lancet. This always takes place when the sucker consists of from four to six pieces. In the latter case two of them represent the mandibles; in the other, or where the sucker is composed of only four setæ, these are wanting, or merely rudimentary. Sometimes also the labrum, almost always vaulted and large, seems to offer the vestiges of another piece, which, under a fuller development, might no doubt be regarded as the epipharynx. Sometimes the support is very short, and in this case the pieces of the sucker leave the cavity of the mouth, and the maxillary palpi are inserted on the sides. The Hippoboscæ, or pupiparous Diptera, differ from all the rest in the absence of the sheath; for the palpi, under the form of two coriaceous elongated blades, perform its functions, and advancing in a parallel direction, cover and protect the sucker.

In accordance with the observations of Latreille, as well as with those of Savigny, Leclerc de Laval, and Professor Nitzsch, regarding the structure of the mouth in such of the hexapod insects as undergo no metamorphosis (*hexapodes homotenes*), the general plan of organization seems in these to be the same as among the polymorphous orders. In *Pediculus*, properly so called, the only known suctorial species of that division, the trunk (*rostellum*) consists of a small inarticulate tube, inclosing a sucker, and withdrawing itself at pleasure within a muzzle-shaped advancement of the anterior portion of the head. But the organization of these parasitical species requires a renewed and more careful examination. The genus *Ricinus*, although furnished with mandibles, maxillæ, and an inferior lip, has these parts greatly concentrated, after the manner of the Suctoria; and the labrum seems to perform the office of a cupping glass, a character unique and unexampled in this class of animals, and one which, in combination with certain other features, indicates a peculiar type.[5]

These are the principal modifications exhibited in the structure of the mouth by hexapod or true insects. In the opinion of Marcel de Serres, the parts named palpi (the antennulæ of some authors) enjoy, at least in the Orthoptera, a peculiar property, that of being the organ of the sense of smell. Lamarck again looks upon the palpi as exercising the faculty of taste. Latreille regards these opinions as ill-founded, so far as concerns a great number of insects, such as those in which the palpi are non-existent, undeveloped, or extremely minute: but he views them in a more favourable light in reference to certain other species. Thus, among the Coleoptera of the sub-family of *Xylotrogi*, the maxillary palpi of the males are laciniated or pectinated like some antennæ. In many other kinds the last article of the palpi is greatly dilated, and terminated by a pulpy substance.

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[1] See Plate CCXX. Fig. 4 represents the mouth of *Cimex nigricornis;* *a* is the articulated labium, with the eyes at each side, and the first joint of each of the antennæ; this is the sheath for the other organs, and exhibits the groove on its oral surface; *b* is the sucker viewed from above, covered at the base for one third of its length by the tubulated labrum, and exhibiting at the extremity the straight united tip of the maxillæ, and the recurved ends of the mandibulæ; *c* is a view of the same parts separated, with the labrum removed to exhibit the expanded roots of the mandibulæ and maxillæ, the small opening of the pharynx, and the pointed lingua before it and between the maxillæ. Fig. 6 represents the mouth of another hemipterous insect, the *Nepa Neptunia* of Savigny, the labrum and palate being removed. The mandibulæ appear at the external sides, their summits with reflected spiculæ, and their roots near the pharynx flask-shaped. The tongue (in the interior of the figure) is trifid at the apex, underneath which the maxillæ arise, and exceed the mandibulæ in length. The labium, or central anterior portion, exhibits the groove for the reception of the other parts, and the oval raised marks towards the narrow end are the (supposed) vestiges of palpi.

[2] *Diction. Classique d'Histoire Naturelle,* t. ii. p. 434.

[3] *Linn. Trans.* vol. xiii. p. 12.

[4] See Plate CCXX. fig. 7, where we represent the parts of the mouth of *Tabanus Italicus.* At *a* the mouth is shown as if opened, or the labrum and the mandibulæ and lingua separated, to expose the pharynx; *b* is one of the mandibulæ viewed laterally; *c* is one of the maxillæ with the articulated palpus, the last joint of which is greatly enlarged; and *d* exhibits the labium, with its fleshy lips.

[5] *Diction. Classique d'Hist. Nat.* t. ii. p. 436.

We have not hitherto attended to the singular order Strepsiptera of Kirby (Rhipiptera, Lat.), the characters of which were first given in the *Linnæan Transactions*. If we regard the insects of this order as possessed of genuine mandibles, we must of course include them among the masticating tribes; but as in many of the preceding orders, in which the parts of the mouth are feebly developed, the mandibles are observed to have become obliterated, there is reason to suspect that the parts regarded as such in Strepsiptera are rather maxillary, in which case the structure would approach that of the lepidopterous kinds.

We have entered into the preceding details in consequence of the great importance which is now attached to the study of the parts of manducation. Latreille indeed seems to be of opinion, that whenever it is possible to characterize genera by more obvious organs, the minuter parts should not be had recourse to; and he deems the principles of the Fabrician system liable to abuse, especially when Clairville's example is departed from of employing only the mandibles and palpi. But the truth is, that the use of the compound microscope is scarcely ever required in these examinations; and it cannot be denied that a knowledge of such essential parts is indispensable in the formation of natural generic groups. The general physiognomy is frequently deceptive, and we can rectify our views only by recurring to influential organs. Thus the *Sphex spirifex*, and some analogous species which differ from their congeners in the mode of providing for their young, and which therefore form a good natural group, are also distinguished by an alteration in the structure of the mouth, but could scarcely be separated from the primitive genus by characters drawn from any other parts.

Besides the parts of the mouth, the head of insects presents some other component portions which have received particular names. What Mr Kirby calls the nose is that upper and anterior portion to which the labrum is attached, and which corresponds to the *clypeus* of Fabricius. (See Plate CCXX. fig. 1, *a*, upper portion.) The latter term was originally applied metaphorically to the expanded or shield-like covering of the head of the Scarabæidæ, and the expression was not inapt; but when it came to be used as a general term in relation to the structure of all other kinds, it lost its propriety of application. Hence the term *nasus* or *nose* has been substituted, as well as that of *epistoma*, which signifies the *part above the mouth*. Between the nose and the labrum we find in many species the nostril piece or *rhinarium* of Kirby. It is very obvious in a New Holland beetle, *Anaplognathus viridiæneus*. The *postnasus* may be seen under the form of a triangular piece, below the antennæ and above the nose, and separated from the latter and from the front by a deeply impressed line. It is very distinct in that splendid Chinese beetle the *Sagra purpurea*. The *frons* or front of insects is the middle part of the face, bounded laterally by the eyes, anteriorly by the nose or after-nose and the cheeks, and posteriorly by the vertex. The *vertex* is the crown of the head, and is bounded laterally by the hinder part of the eyes and the temples, and posteriorly by the occiput, when that part exists. It is the ordinary region of the stemmatic eyes, although these peculiar organs are sometimes found to occur likewise upon the frons. The *occiput*, or hind head, is that part which either forms an angle posteriorly with the vertex, or slopes downwards from it. It is bounded laterally by the temples, and posteriorly by the orifice of the head, or by the neck itself. The cheeks, *genæ*, according to Kirby, usually surround the anterior part of the eyes, lying between them and the mandibles, or their representatives. The temples, *tempora*, form a continuation of the cheeks to the posterior limit of the head, forming its sides and posterior angles.[1]

The *subfacies* of an insect is the lower surface or under side of the head, and is composed, 1*st*, of the *lora*, a corneous angular machine, upon the intermediate angle of which the mentum sits, and on the lateral ones the cardines or hinges of the maxillæ: it is by means of this piece that the parts of the mouth (as in *Hymenoptera*) are pushed forward or retracted: 2*d*, of the *jugulum* or throat, which is that part of the subface which lies between the temples. The *collum*, or neck, is that narrow portion of a pedunculate head by which it is connected with the thorax.[2]

The next appendages of the head to which we have to direct the reader's attention are the *antennæ*. These are moveable articulated organs, never exceeding two in number in genuine insects, although their form, and the amount of articulated portions, are extremely various. Their primary use in the animal economy has not yet been ascertained: at least a great diversity of opinion is maintained on the subject. In numerous tribes they seem to exercise a faculty analogous to that of touch, being employed in exploring the depth of crevices, and in ascertaining by contact the nature of any opposing obstacle; while, on the other hand, their extreme shortness in most Diptera, and in many of the neuropterous and hemipterous tribes, does not accord with that usage. Although of considerable importance in our systematic arrangement of insects, the development of the antennæ does not seem subjected to any general or conformable rules, and is therefore of less value than that of several other parts of structure. For example, we frequently find a considerable difference to exist in the form of the antennæ among species in other respects intimately allied; and even between the sexes of the same species a great disparity in size and structure is observable. Where a difference exists, those of the male are generally more developed than those of the female.

The antennæ of insects are usually composed of small cylindrical articulations, containing nervous threads, muscles, tracheæ, and cellular tissue. Various terms are in use to express their form, consistence, and mode of insertion. They are *regular* when the articulations follow a gradual and progressive order in the modifications which they undergo: *irregular*, when their forms alter suddenly; *cylindrical*, when rounded and of equal diameter throughout their length: *filiform*, when the cylindrical shape is finely attenuated, like a thread or hair; *setaceous*, when lengthened, and diminishing insensibly from the base to the point: *subulated* or *awl-shaped*, when slender, but short, cylindrical at the base, and terminated by a stiff and sharpened point: *moniliform*, when each article is rounded like a bead, and of nearly equal thickness; *prismatic*, when approaching the form of a geometric prism: *ensiform*, when broad at the base, and terminated by an angular point: *fusiform*, when shaped like a spindle; *serrated*, when each article is terminated laterally by a sharp tooth directed forwards; *pectinated*, when these projections are straight, lengthened, and placed above each other, like the teeth of a comb; *ramose* or *branched*, when several appendages project from the main body of the antennæ—they are regarded as *simple* when not in any way so adorned: *perfoliated*, when the articles are flattened from the summit to the base, and appearing as if strung on a thread through the centre (it is usually the terminal portion of the antennæ that is so characterized); *imbricated*, when the articles are threaded as above mentioned, and concave at their summit, so that each covers the base of that which follows: *clavated* or *club-shaped*, when thick or swollen towards the summit. The club is *solid* when its parts are not separated by any apparent space; *perfoliated*, when composed of threaded articulations; *lamellated* or *foliated*, when the parts of the club are connected laterally, and admit of being opened and closed like the leaves of a book; *securiform* or *hatchet-shaped*, when the last articulation assumes the form of a compressed triangle, free at the base, but articulated by the apex. Antennæ are also said to be *uncinated* or *hooked* when the extremity suddenly bends itself towards the base; *bifid*, when divided into two: *obtuse*, when terminated by a round or blunted articulation; *truncated*, when apparently deprived of a portion; *plumose*, when thickly branched on either side, like a feather. Many other terms are in use to express the modifications of these important organs, most of which, however, are of a sufficiently familiar derivation to explain themselves.

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[1] *Introduc. to Ent.* vol. iii. p. 483.

[2] *Ibid.* p. 366.

The antennæ of the coleopterous order usually consist of ten or eleven distinct articulations. The latter number is the most frequent, although several genera present much fewer joints, as for example *Paussus*, in which there are only two. Others again have many more, such as a species of Prionus, of which the antennæ of the female have nineteen joints, of the male twenty. In some orthopterous kinds these articulations amount to a hundred and fifty. The antennæ are inserted on the front of the head, anterior to and rather beneath the region of the eyes. Their particular position varies, but they are always either in the space between the eyes, or that below them. As their various forms, as characteristic of particular groups of species, will be afterwards described in the systematic part of the present treatise, we shall not here enter into further details of structure. The uses of these singular organs are variously viewed by naturalists, and there seems even yet to be more hypothetical reasoning on the subject than precise induction from facts. Some regard them as the seat of smell, others of hearing, a greater number as the organs of the sense of touch. The indurated nature of the outer covering in most insects would certainly lead us, *a priori*, to expect a special provision for the reception of the last-named sense. It is, however, extremely difficult, in the present state of our knowledge, to come to any general conclusion on the subject. We shall state the prevailing opinions when we come to treat of the senses of insects: and under that head we shall likewise explain the structure of the eyes.

The *thorax* forms the second principal portion of an insect's body. It is itself divisible into three parts, and its component segments vary greatly in their relative proportions in the different tribes; the division which is merely rudimentary in one particular group, being sometimes highly developed in another. These parts are named the *prothorax*, the *mesothorax*, and the *metathorax*.

The *prothorax* (from προ, *before*, and θωραξ, *thorax*) is the anterior segment, and corresponds to the *corselet* or collar of M. Latreille: the second segment is named *mesothorax* (from μεσος, *middle*); and the third is known as the *metathorax* (from μετα, *after*.) Each segment may likewise be distinguished in reference to its inferior, its lateral, and its superior portions; and the whole united constitute the *thorax*, commonly so called. But although the general name of thorax is applied to the parts just named, yet the posterior two, that is, the mesothorax and the metathorax, are the most dependent on each other, and are always intimately united: while the prothorax, as exemplified in the Coleoptera, is often comparatively free and distinguishable. It is this last-mentioned segment which bears the anterior pair of feet, and it considerably exceeds the others in extent. In the coleopterous order, indeed, it is the only part that is visible on the upper surface, the other segments, with the exception of the scutellum, being connected beneath it and the elytra. The mesothorax and metathorax unite strictly with the base of the abdomen, and serve as the points of attachment to the other pairs of feet. Of the mesothorax or central portion, the most obvious characters consist in its serving as a support to the second pair of feet, and to the elytra or first pair of wings. Its form, size, and consistence are extremely various. Slightly developed in the Coleoptera and Orthoptera, it is larger in the Hemiptera, the Neuroptera, and more especially in the Hymenoptera, the Lepidoptera, and the Diptera. Its excessive increase is always associated with a condition more or less rudimentary of the other segments. Thus, in the three orders last named, the prothorax and metathorax are very restricted; while, on the contrary, they are large in the Coleoptera, among which it is observable that the mesothorax is always compressed and narrow. The metathorax serves as the point of attachment to the third pair of feet, and to the second or membranous pair of wings.

We have said that each segment may be described in relation to its inferior, its lateral, and its superior parts. A piece named the *sternum* constitutes the whole of what is called the *inferior* portion. This is not, as too often supposed, an occasional projection, merely characteristic of certain tribes. It occurs in all insects, and forms a distinct character, though more or less defined and perspicuous, according to the genus. It may be regarded as generally composed of three distinct pieces, resembling in this respect the human sternum, which anatomists describe as consisting originally of three bones. Each of these pieces, according to Mr Kirby, is appropriated to a pair of legs, and each of them has been called the *sternum*; thus, in Elater the *prosternum*, in the Cetoniadæ the *mesosternum*, and in Hydrophilus the *metasternum*, have alike been distinguished by the name. Each of the ordinary *lateral* portions of the thorax is formed of two principal pieces, which, in combination with the sternum, is by some named the *pectus* or breast. The anterior piece rests upon the sternum, and is hence called *episternum* (from επι, *upon*). The posterior lateral portion, called the *epimera*, is connected with the preceding: it also adheres to the superior portion, and rests in certain cases on the sternum; but it bears a constant relation to the haunches of the segment to which it belongs, and to these it articulates by means of a little piece afterwards mentioned by the name of *trochantin*. It derives its name from επι, and μηρος, *thigh*. Lastly, there exists on these same lateral parts a third piece, in general slightly developed, and sometimes imperceptible. It bears relation to the wing and episternum, always supports itself on the latter, is sometimes prolonged inferiorly along its anterior margin, or, becoming free, passes in advance of the wing, or even places itself above it. It bears the name of *paraptera*, from παρα, *near to*, and πτερον, *wing*. Three other portions of some importance may likewise be considered as belonging to the general *pectus*.

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1*st*, Above the sternum, on its internal face, that is, within the body of the insect, there exists a piece sometimes remarkable for its size. It is placed on the median line, and generally takes its rise from the posterior extremity of the sternum. It assumes various secondary forms, and is generally divided into two branches. Cuvier named it the Y-formed portion, on account of his having observed it assume the shape of that letter. It is called *entothorax* by M. Audouin, from εντος, *within*, because it is always placed in the interior of that organ. It occurs in each segment of the thorax, and seems to be in some measure a dependent on the sternum. Its uses are supposed to be the protection of the nervous system, and its isolation in many cases from the digestive apparatus and the dorsal vessel. The entothorax exists not only in the thorax, but in the head, in which case it is named *entocephalus ;* it has even been noticed in the first ring of the abdomen in the genus *Cicada*, and the portion named *triangle écailleux* by Réaumur may safely be regarded as its analogue. In this last condition it is denominated *entogaster*.

2*d*, On the anterior edge of the episternum, sometimes of the sternum, and even on the superior part of the body, a stigmatic opening is observable, surrounded by a small piece, of which the texture is frequently corneous. This is the *peritrema*, so called from περὶ, *round about*, and τρῆμα, *a hole*. It is not always perceptible, both on account of its being sometimes too closely connected with the neighbouring pieces, and because the stigmatic opening is itself sometimes obliterated. But when visible, it is necessary that it should be distinguished, as its position is of importance, and becomes a useful auxiliary in the comparison of parts and in the determination of analogies.

3*d*, Lastly, it has been already stated in relation to the epimera, that it is connected with the rotule by means of a small articulation, of which the existence was first made known by M. Audouin. This is not an essential part of the thorax ; but as it accompanies the epimera, and is associated with the parts of the leg, all of which have received particular denominations, its first describer has thought proper to bestow upon it a name. He calls it *trochantin*, in distinction to *trochanter*, or that portion of the leg which is associated with the rotule and the thigh. The trochantin is sometimes concealed in the interior of the thorax, and is sometimes visible externally, according as the rotule is itself more or less prolonged in its internal portion. The ascertainment of this piece, according to M. Audouin, admits of a direct comparison between the limbs of insects and those of the Crustacea. Hitherto there were only five parts in the former (the tarsi being regarded as one), while there were six in the latter. But the trochantin completes the number six likewise among the insect tribes.

We have now detailed the structure of the chest or pectus of insects ; so that whoever desires to view one of these creatures anatomically, should, after dividing the thorax into three segments, seek to ascertain, on the inferior and middle portion of each, the existence of a sternum, and on the flank or lateral portion, an episternum, a paraptera, and epimera. He will also study the structure of the entothorax, of the peritrema, and of the trochantin. Sometimes, however, the union of one or more of these parts with another is so intimate that they cannot be isolated or distinguished ; but when we elsewhere, in such numerous cases, perceive that the pectus is formed of a certain number of elementary parts, it is more rational to believe that in all instances these same elements are made use of, than to suppose the frequent requirement of new.

We shall next discuss the superior portion of the thorax of insects. In the coleopterous tribes the prothorax, as before mentioned, constitutes the principal portion, and its upper part may be called the *thoracic shield*. The only other part sufficiently distinguished prior to the time of M. Audouin, was the *scutellum* or escutcheon. It is highly developed in the Scutelleræ, and rudimentary in most of the Hymenoptera, Diptera, Lepidoptera, and some other orders. Its apparent position between the wings has occasioned its being regarded too exclusively as a kind of *point d'appui* in flight. It is usually of a triangular form in the Coleoptera, and projects backwards from the mesothorax, with its point interposed between the elytra and the wings. The scutellum was adopted by Geoffroy as the basis of his arrangement of the genus *Scarabæus*. It is, however, by no means a well-chosen characteristic of the greater divisions in entomology ; for the accurate distinction is not, as is usually supposed, whether the scutellum does or does not exist in a lamellicorn insect, but whether it is or is not apparent.[1] It occurs very obviously among many of the coleopterous tribes, but is most conspicuously developed in that genus of the hemipterous order called *Scutellera*, of which *Cimex lineatus* may serve as an example. Naturalists have erred in regarding this portion as characteristic of the mesothorax alone. It is often greatly developed in the posterior segment. Numerous and varied researches have led M. Audouin to conclude that this superior portion of the thorax is composed of four principal pieces, frequently isolated, sometimes intimately united, usually distinct. He has deduced the following nomenclature from their relative position in regard to each other. The anterior portion is named the *præscutum ;* it is sometimes very large, and is usually concealed in whole or in part in the interior of the thorax. The second piece is called the *scutum ;* it is an important element, often strongly developed, and always articulates with the wings when these exist. To the next piece the original term *scutellum* is applied ; it consists of the projecting angular point, generally so denominated by entomologists. The fourth and last piece is called the *postscutellum ;* it is almost always entirely concealed within the thorax, sometimes united to the internal face of the scutellum, and confounded with it, sometimes free, and not adhering to the other portions, except by its lateral extremities. These are the parts which constitute the superior portion of the thorax, and to which the general term *tergum* may be applied. Thus we may speak of the tergum of the prothorax, of the mesothorax, or of the metathorax ; but when the word tergum alone is used, we are then understood to signify the union of the superior parts, that is, the entire space comprised between the head and the first segment of the abdomen.

We come now to the *abdomen* itself, an important portion in the animal economy. Anatomists in general appear to have advanced from the study of the human frame to that of animals, or at least to have applied to the parts of the latter the same terms which they had previously bestowed upon the former. In so doing, however, they have been guided rather by the analogy of form than of function, and hence the vague nature of many terms, as applied to the inferior orders, and which, however correct in their original signification, become either obscure, or altogether inapplicable in regard to other classes.

The abdomen, among insects, is that part of the body which is attached to the posterior extremity of the thorax, composed of five or six rings or segments, unprovided with locomotive organs, and always containing within it a portion of the digestive canal. If, as many suppose, its existence depends upon that of the thorax, then the entire class of Annelides or red-blooded worms may be said to be deprived of it, as the thorax itself does not exist in that class.

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[1] *Horæ Entomologicæ*, part i. p. 9.

The term body is then made use of to designate generally the whole of the animal. Although the abdomen cannot well exist without the thorax, the converse does not appear to hold good, for the latter in many species seems to constitute the whole body. Many of the *Myriapoda*, such as Iulus and Scolopendra, are examples of this; for they are composed of a series of segments, all furnished with feet except the last, which has therefore by some been regarded as the abdomen.

But among genuine insects, that is, the hexapod or six-footed kinds, the abdomen is obviously developed, and, especially among the winged tribes, is very distinguishable from the thorax. Among the apterous species the distinction is less perceptible; and the same may be said of most insects in the larva state. Among the hymenopterous kinds, such as wasps, bees, &c. it appears as if it were pediculated or attached to the posterior part of the thorax by means of a slender stalk; but minuter and more accurate observation demonstrates that this neck-like restriction actually takes place on the second segment of the abdomen, the first of which is much more spacious, but so closely attached to the thorax by its anterior edges as to become undistinguishable. In the coleopterous order the abdomen is usually convex, and of a harder consistence beneath, where it is exposed; but it is soft, and either flattish or concave above, where it is covered by the folded wings and elytra. On both sides of its segments there is a small roundish opening called the *stigma*, which serves for the introduction of air for the purposes of respiration, and of which we shall treat in detail when we come to the consideration of that function.

It has been noted that if an insect is naturally more habituated to walking than flying, the breast or lower portion of the thorax is expanded, and is furnished with more powerful muscles than the back; whereas, if flight is the more frequent mode of locomotion, an increase is observable in the dorsal muscles. The locomotive organs are of course the wings and legs, on which we shall now bestow a brief consideration.

SECT. III.—ORGANS OF LOCOMOTION IN INSECTS.

1. *The Wings.*

These organs exist, effectively, in insects only in the perfect state; for the larvæ do not offer externally any trace of them, and when apparent in the nymph or intermediate condition, they are merely rudimentary. No insect has more than four wings, many have only a single pair, and others are entirely destitute of these parts. When four in number they may be regarded as *anterior* or *superior*, and as *posterior* or *inferior*; and we likewise talk of the *first* or of the *second pair* of wings. The coleopterous order presents some peculiarities in relation to these organs. The anterior pair (in all cases, as already mentioned, united to the mesothorax) consist of a hard or horny substance similar to the envelope of the thorax, and are called *elytra*. When closed, their junction usually forms a straight central line called the *suture*, which is rather apparent than real in certain species in which the inferior wings are wanting, and the elytra form a single undivided piece. They are convex above and concave below, are fixed to the mesothorax, and cover and protect the genuine wings, which are of a much more delicate structure. These latter derive their origin from the metathorax, and are the actual organs of flight. They are membranous and transparent, and when unemployed are transversely folded beneath their horny covering. We shall here describe the structure of wings, and explain the terms made use of to express the principal modifications which they undergo in their various degrees of development in the different orders.

The wing of an insect consists of two thin flexible membranous transparent plates or leaves, the one superimposed upon the other, and variously intersected by darker lines of a horny consistence, usually known by the name of nervures. These nervures, which at first sight appear like superficial threads, of which the larger follow the longitudinal direction of the wing, are interposed between its membranes, and present two faces, of which the upper, frequently rounded and very horny, adheres closely to the corresponding leaf, and the under, of less firm consistence, and of a flatter form, may by skilful dissection be removed from that portion of the wing by which it is covered. In the opinion of M. Audouin, these threads are in fact so many tubes, which diminish in diameter as they approach the summit of the wing, and each of which contains, throughout its entire extent, a spirally rolled vessel, by some regarded as a genuine trachea. These tracheæ receive air from the interior of the body, and their formation, according to Swammerdam, whose views have more recently been confirmed and adopted by Jurine and Chabrier, is to strengthen the wing by distending it during the action of flight. They are said to experience no sensible dilatation during their progress, whereas the corneous tubes which contain them present in that respect some curious modifications,—for they sometimes spread out suddenly, in such a way as to exhibit, for a short space, a comparatively broad diameter. The colouring matter being then disseminated over a wider surface, assumes so pale an aspect that the nervure which leads into one of those little expansions appears as it were interrupted. Hence the name of *bulles d'air*, or air-bubbles, bestowed upon the latter by the French entomologists. They occur most frequently in the cubital nervures of many Hymenoptera, and their chief use is supposed to be to facilitate the formation of certain foldings of the wing during the periods of repose. The largest of the nervures arise from the base of the wing, that is, from the point of its insertion in the thorax. A most skilful observer, the late M. Jurine of Geneva, has described the wings of hymenopterous insects with great accuracy, in a memoir to which we shall make more special allusion when we come to treat of that particular order.[1]

The general character in respect to form and aspect of the wings of insects has received a great variety of names. They are sometimes *equal*, that is, all four of similar size; or *unequal*, when one pair prevails over the other; *lanceolate*, when they become narrow, both at the base and apex; *falcated*, when curved like a scythe or reaping-hook; *linear*, when narrow, with nearly parallel edges; *clavated* or *club-shaped*, when linear in their general extent, but perceptibly enlarged towards their extremity; *rounded*, when they approach a more circular form; *oblong*, when more lengthenened than broad, and describing an elongated ellipse, obtuse at both ends; *rhomboidal*, when they are longer from the posterior angle to the summit than from that angle to the base; *deltoid*, when they assume the triangular form of the Greek letter delta; *exserted*, when the inferior wings pass beyond the elytra; *covered*, when entirely protected by those organs; *plaited*, when longitudinally

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[1] See *Observations sur les Ailes des Hyménoptères*, in the twenty-fourth volume of the *Mem. de l'Académie des Sciences de Turin.* Consult also, by the same author, *Nouvelle Méthode de classer les Hyménoptères et les Diptères.* Genève, 1807.

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folded, after the manner of a fan; *replicated,* when, after being plaited as just mentioned, they are again folded transversely upon themselves; *incumbent,* when the posterior margin of one covers that of the other; *extended,* when, in a state of repose, they are stretched on either side, leaving the abdomen visible; *erect,* when, in a state of repose, they are raised perpendicularly to the surface of the body; *deflexed,* when the summits and outer margins form as it were a kind of inclined plane from the base and inner margins. These are the principal variations as to form and attitude, or position. The following terms are of frequent use in entomology, when the surface or superficial structure of the wings is sought to be described. They are *striated,* when certain raised lines are perceptible, forming slight parallel and longitudinal furrows; *reticulated,* when these lines are disposed like lace or network; *veined,* when distinct longitudinal nervures are observable, ramifying into more delicate branches; *squamous* or *scaly,* when covered with minute powdery particles, which, when examined with a glass, are found to be small scales imbricated or imposed on each other like slates or tiles on a house top; *farinose,* when sprinkled more irregularly with fine particles resembling flour, and easily removeable by the finger; *pilose* or *hairy,* when the surface is more or less covered by minute hairs; *naked,* when there is no covering of either hairs or scales. Other characters are deduced from the markings of the wings in regard to tint and colour. They are *concolorous,* when similar or unvaried in their hue; *vitreous* or *windowed,* when, opake over their general surface, certain translucent spots are here and there observable; *ocellated,* when they present circular spots of different colours, resembling an eye; *pupillated,* when the eye-like spot has a coloured point in its centre; *fasciated,* when there are broad coloured lines or bands,—and these are distinguished as transverse, longitudinal, oblique, lanceolated, &c. according to their prevailing direction and characteristic form.

The margins or edges of the wings have likewise received a considerable variety of designations, according to the peculiar characters which they exhibit. They are *crenated,* when they present an alternation of slight incisions and obtuse projections; *dentated* or *toothed,* when these incisions are deeper and narrower, and the projections sharper and more defined; *fimbriated,* when the marginal processes are lengthened, pointed, and close; *cloven,* when the incisions are few and deep; *digitated,* when the parts cut into assume the aspect of a hand; *emarginate,* when the incision is slight, and seems merely to have scooped out a small portion of the wing; *caudated* or *tailed,* when the posterior margin presents a more lengthened appendage; *ciliated,* when the wings are bordered by close-set hairs resembling eye-lashes. The points of the wings are *obtuse,* when terminated by a rounded outline; *truncated,* when they appear as if cut; *acute,* when ending in a point; *acuminated,* when that point is sharp and prolonged.

These details, we doubt not, like all the other technicalities of a complex branch of science, must seem irksome to the general reader. Nevertheless, as they frequently form important and sometimes indispensable elements of knowledge, we must continue their enumeration. The wings, in fact, have furnished the characters from which the names and definitions of the orders in entomology have been derived, and a knowledge of their forms and functions is required during almost every step of our progress. A transcendental anatomy has no doubt thrown its ambiguous light (*lucus a non lucendo*) upon these and other portions of animal economy; and the wings, which in former times were thought sufficiently defined when merely named as the organs of flight, are now regarded by some as legs, and by others as lungs. We still see, however, that they carry the creatures through the air, and we shall therefore rest satisfied by viewing them in accordance with our accustomed associations.

Among the more remarkable of the modifications experienced by the upper wings, is that corneous condition in which they are known under the name of *elytra.* These are particularly characteristic of the coleopterous order, and derive their name from ἔλυτρον, a sheath or covering, because they protect the membranaceous wings. They are attached by their base, by means of several small pieces, to the mesothorax. The opposite extremities are called the points or summits, and the margins are known as anterior or external, posterior, and interior,—the last named, when the parts are closed, and meeting over the back, forming what is called the dorsal suture. As to their proportions, they are *elongated,* when they exceed the abdomen; *abbreviated,* when shorter than that organ; and various other terms of obvious application are made use of to express their different degrees.

The elytra differ in their consistence, being sometimes almost *membranous,* or scarcely firmer than the under wings; or they are *coriaceous,* or of the texture of leather; *semi-coriaceous,* when, as among many Hemiptera, the elytra are composed of two parts of different texture; *pergameneous,* or like parchment; *flexible,* when, yielding to a slight impression, they yet return again immediately to their original shape; or *soft,* when they yield to the same impression, but retain the alteration of form for a longer time. As to form, many of the terms already enumerated in relation to the wings in general, apply equally to the elytra. They are also *gibbous,* when greatly rounded or hemispherical; *dilated,* when more flatly expanded; *attenuated,* when they diminish in breadth from the base to the apex. The surface of these parts presents many characters of great importance in the discrimination of species, and even in the formation of sections or subdivisions of genera. They are said to be *chagrined,* when covered by minute *raised* spots; *punctated,* when these spots are distinct and *hollowed; tuberculated,* when the elevations are distinct and irregular; *scabrous,* when the elevations are distant and unequal; *verrucose* or *warty,* when they are large, cicatrised, and resembling warts; *striated,* when marked with regular longitudinal lines; *striato-punctate,* when in each stria there are depressed points; *punctato-striate,* when the striæ are themselves formed by a consecutive series of these impressed points; *sulcated* or furrowed, when the impressed lines are deep and broad; *ribbed,* when between the furrows there are raised lines; *rugose,* when the raised lines are irregular, and divided in all directions; *reticulated,* when these lines are disposed with greater regularity, in a kind of network; *crenated,* when the lines are rather regularly undulated; *glabrous,* when the elytra are smooth, or destitute of raised points or other irregularities of surface; *tomentose* or *cottony,* when covered by a whitish down; *pilose,* when hairy,—also *villous; fasciculated,* when the hairs are collected here and there in little tufts; *muricated,* when the hairs are long, raised, and almost prickly; *spinous,* when the projecting parts are hard and sharp like spines; *squamous* or *scaly,* when covered by little scaly plates.

The elytra are said to be *margined* when their edges are raised, or otherwise distinguished from the general and more central surface; *sinuated,* when there are sloping notches on their outline; *serrated,* when furnished with little sharp projections like the teeth of a saw; *dentated,* when these are sharp and more distant. They are likewise said to be *mucronated* when the apex is provided with a sharpish point; *bidentated,* when there are a couple of distinct projections; *obtuse,* when the summits are blunt or rounded; *truncated*, when they seem as if a portion had been severed.

We have already mentioned, that in many of the hemipterous order the anterior wings are *semi-elytrous*, that is, comparatively solid in one part of their extent, and membranous in the other. In fact, the order derives its name from that character, as already mentioned in our introductory definitions. In the orthopterous order the anterior wings, though much more membranaceous than those of beetles, yet approach the nature of elytra, and serve as a protection to the under pair, which are more delicate. Among neuropterous insects both pairs of wings are alike in their general character of texture and reticulation, and the same may be said of the hymenopterous order. Those of the Lepidoptera are also similar to each other in their substance and covering. With a few exceptions, in which the wings are clear or diaphanous, in the last-named gorgeous group they are thickly coated with minute scales of various colours, which when removed exhibit the membranous structure of the parts. They present several other peculiarities, which we shall notice when we treat of the generalities of the greater divisions of which the order is composed.

The wings, regarded throughout the entire series of hexapod insects, are thus extremely varied in their form, consistence, development, and efficiency. The distinctions, both of form and texture, show themselves, as it were, by gradation, and present no striking disparity among species otherwise nearly allied. But the uses, and degrees of development, of these organs, vary greatly not only among species of the same genus, but even between the sexes of the same species; for while the males of several kinds are efficiently winged, the females are entirely apterous. When the anterior wings, as in the Coleoptera, are *elytrous* (if we may use the expression), they scarcely serve for the purposes of flight. In the neuropterous and hymenopterous orders both pairs are equally efficient, while in the dipterous or two-winged tribes the inferior wings have disappeared. In some cases, as among the female ants, the wings fall off immediately after the sexual union.

The development of the wings always bears a relation to that of the superior arc of the thorax by which they are supported. It has been already noted, that if an insect is more habituated to walking than flying, the breast or lower portion of the thorax is extended, and is furnished with more powerful muscles than the back; whereas if flight is the means of locomotion, an increase of power is observable in the dorsal muscles.

One of the laws laid down by M. Straus Durckheim as regulating organic structure is the following:—that when one organ governs another, or several others, these follow the march of the dominating organ; and that when the latter disappears, those which were subordinate to it immediately assume their primitive form. This law may be exemplified by the influence of the wings upon the thorax. In proportion as the two pairs of wings change in form and size, the two segments of the thorax which support them follow the same progression, and become more and more united to each other; but no sooner do the wings disappear in the Aphaniptera (Pulex), than the two segments of the thorax regain their primitive form, and separating from one another, present the same appearance as in Lepisma. The wings being first introduced amongst the Coleoptera, and the thorax of these as yet differing but little from that of the Thysanura, it can easily return to the form it possessed previously to its undergoing any modification. It thence follows, that in such species as are deprived of wings, the thorax returns more or less to its primitive form. This is particularly remarkable in the females of many species of *Lampyris*, which possess neither wings nor elytra; and this return is moreover occasioned in the Coleoptera without wings by another cause, which acts in this case on that part of the body; it is the diminution of the solidity of the integuments in those parts which are covered by the elytra.

In the other order of insects, according to the views of the last-named author, the two segments which bear the wings having already experienced a very considerable change of form, it would require a very powerful cause to bring them back to their primitive form; for this reason the return does not take place in *Cimex cellularius*, the *Formicæ*, &c. amongst which the imperfection (if it may be so called) is only specific. In the Aphaniptera, on the contrary, which we may in some respects consider as wingless Diptera, the transformation of the thorax takes place in consequence of a complete absence of the wings, brought about by the degradation which these organs have experienced in passing through the whole of the class Insecta.

M. Straus Durckheim, in the introduction to his carefully elaborated work,[1] has also endeavoured to explain the laws which regulate the different changes of structure in passing from one group to another. The most general law in the organization of animals which he has recognised is, that all the systems of organs are subjected to a constant variation of form, and even of function, while passing from one family to another. The first more special or particular law which he evolves from the subdivision of the former is the following: That the organs at one extremity of the scale always exercise a very evident function; whilst at the other extremity they are constantly rudimentary and without function, and at last entirely disappear. He here distinguishes two kinds of cases. In the first, the organs present themselves at the head of the scale developed to the highest degree of which they are susceptible, and decrease insensibly, until they arrive at the other extremity of the scale. Thus, for example, the posterior wings of insects are "introduced suddenly" into the organization of that class at the highest point of perfection in the Coleoptera, where *they* alone serve for flight. In the Orthoptera and Hemiptera they already begin to divide their function with the elytra, and go on diminishing gradually until they exist merely as rudiments in the Diptera, where they are represented by the halteres.[2] Finally, they entirely disappear in the Aphaniptera. In the second instances, the organs do not appear at the head of the scale in their most perfect state of development, and only acquire it by degrees. Such is the case with the elytra, or first pair of wings, which follow a course exactly contrary to that of the inferior wings. They only appear at first as organs slightly accessory to flight, in which state they remain nearly throughout the whole Coleoptera. In the Orthoptera and Hemiptera they begin already to take a very active part in

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[1] *Considérations Générales sur l'Anatomie Comparée des Animaux articulés, auxquelles on a joint l'Anatomie descriptive du Hanneton*, 1 vol. 4to, avec planches, Paris, 1828. An abstract of the doctrines of this work will be found in the *Entomological Magazine*, vol. i.

[2] The name of *Halteres*, poisers or balancers, is bestowed on a pair of slender moveable appendages found on the hinder part of the thorax in dipterous or two-winged insects. They are usually regarded as the rudiments of the second or posterior pair of wings,—"halteres rudimenta alarum posticarum," as Fabricius has expressed it in his *Entomologia Philosophica*. This opinion, however, is believed by others, and we think with reason, to be founded rather on the position which these organs bear in relation to the anterior wings, than on their connection with the metathorax and its different parts. Latreille, a great authority in such matters, maintains that the balancers do not correspond to or represent the second pair of wings, but are rather vesicular appendages connected with two posterior tracheæ of the thorax, and analogous in some measure to the processes which accompany the respiratory organs of the Aphro-

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flight, but still preserve their primitive use. In the Neuroptera, particularly the Libellulina, they attain the development of the inferior wings, from which they differ but very slightly. From this point they continue to surpass them, until in the Diptera they become the sole organs of flight, and of course have there attained their highest degree of perfection. Arrived at this culminating point, they suddenly diminish in Hippobosca, and entirely disappear in Pulex.

We shall next devote a few lines to those portions of the wings called *ailerons* by the French naturalists, known also under the name of winglets or *alulæ*.[1] They are chiefly characteristic of the dipterous tribes, and may be regarded as appendages of the anterior wings, the sole pair in that particular order. Their attachment to the scutellum and the postscutellum of the mesothorax is sufficient evidence that they are not the rudiments of a posterior pair; for these, if they existed, would derive their origin from the metathorax. They usually consist of two concavo-convex pieces, intermediate as it were between the wing and the poisers, and folded the one upon the other, like the parts of a bivalve shell when the insect is at rest, but stretched or extended during flight. Their special uses are not yet known.

The poisers or balancers (*halteres*) have been sufficiently described in the preceding note. Audouin regards them as the rudiments of the second pair of wings, of which the extreme tenuity in the Diptera accords in his opinion with the evanescence of the metathorax.[2] Their use, like that of the last-named organs, seems not to have been satisfactorily determined. Dr Derham and others have thought that, like the pole of a rope-dancer, they keep the body steady in flight; while some connect them with the noises produced by insects, and maintain that they act upon the membrane of the winglet, as a drumstick acts upon its proper organ, thus producing sound. Shelver's opinion is probably more correct, that they are connected with the function of respiration.[3] But the various sentiments on the subject are as yet conjectural.

2. *The Legs.*

Having now endeavoured to explain the structure of the wings or organs of flight, we shall next request the reader's attention to those other organs of motion, the legs of insects. With the exception of the Myriapoda (*Centipedes*, &c.), which, with Latreille and Dr Leach, we shall form, as already noted, a separate class, the number of legs in insects is precisely six. They are composed of the following parts: 1*st*, The *coxa* or haunch, which is the first joint, or that which plays in the socket (see Plate CCXX. fig. 2, *a*); 2*d*, the *trochanter* or second joint, to the side of which the thigh is attached, and by means of which it inosculates with the coxa (Ibid. *b*); 3*d*, the *femur* or thigh, which is long, and usually compressed (*c*); 4*th*, the *tibia* or shank, generally the longest joint of the leg, and frequently notched on its edges, and terminated by spur-like appendages (*d*); 5*th*, the *tarsus*, composed of articulate portions, varying from three to five among the Coleoptera and the majority of insects (*e*). The last articulation of the tarsus bears the *ungues* or claws (*f*). M. Audouin and some other French naturalists seem to use the term haunch (*hanche*) as a collective designation, including an internal portion formerly noticed, called *trochantin*, along with the *rotule* (our coxa), and the trochanter. In accordance with this view, the parts of the leg in insects may be said to amount to six pieces, instead of the five which we have just enumerated. These terms apply strictly to the intermediate and hind legs. The anterior pair are by some writers regarded as *brachia* or arms. The first joint of the brachium, answering to the coxa of the legs, is named *clavicula*, or the clavicle, by Mr Kirby; its second joint, answering to the trochanter of the other limbs, is called the *scapula*; the third and elongated joint, corresponding to the femur, is designated the *humerus*; while the articulations of the tarsus are known as the *manus* or hand. However, the majority of authors seem not to express any distinction between the parts of the fore legs and those of the intermediate and hind ones. The anterior pair, we may observe, are in some cases convertible into organs of prehension, and their tarsi are frequently dilated in the male sex. The number of articulations of the tarsi varies in the different tribes, and is not always the same in the different pairs of legs in the same insect. Their amount on each limb has been assumed as a basis for the formation of the great sectional divisions of the coleopterous order, as originally proposed by M. Geoffroy, and so generally adopted by the continental naturalists. The character, though arbitrarily chosen, and not seldom artificial in its results, has proved upon the whole more compatible with a natural arrangement than usually happens on the selection of a single and uninfluential organ. We shall enter into further details in relation to this matter in our introduction to the coleopterous order, and shall merely observe in the mean time, that pentamerous species, or those of which all the tarsi are furnished with *five* articulations, are the most abundant,—more than one half of the coleopterous kinds being referable to that section.

These are the principal external parts of the structure of insects.[4] Their internal conformation has been illustrated of late years by the successful efforts of several very skilful and ingenious observers. We shall here notice the dominating or more influential organs, and give a short view of the important vital functions which they exercise.

CHAPTER III.

THE INTERNAL STRUCTURE AND PHYSIOLOGY OF INSECTS.

SECT. I.—THE NERVOUS SYSTEM AND SENSES OF INSECTS.

The nervous system of animals in general, it has been remarked, is one of the most wonderful and mysterious works of the Creator. Its pulpy substance is the visible medium by which the governing principle (Το ʽΗγεμονικον) transmits its commands to the various organs of the body, which instantaneously obey the impulsive mandate; yet this appears to be but the conductor of some higher principle, or

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dites, or those of the aquatic larvæ of Ephemeræ and the genus Gyrinus. He founds his opinion chiefly on this, that the inferior wings always take their origin from the lateral and anterior summits of the third thoracic segment, at a very short distance from the superior wings, and always in advance of the two posterior stigmata of the thorax, whilst the balancers are inserted lower down at the internal extremity of these air-conduits, or close by them. (See Latreille's observations in the 7th and 8th volume of the *Memoires du Museum d'Histoire Naturelle.*)

[1] We have made use of the term *wing-scale* in the systematic exposition afterwards given of the order Diptera. Meigen uses the German word *schuppchen* (squama) in his *Zweiflugeligen Insecten.*

[2] *Dict. Class. d'Hist. Nat.* t. ii. p. 141.

[3] Wiedeman's *Archiv.* ii. 210.

[4] For some additional details, we beg to refer to a paper entitled "Osteology, or External Anatomy of Insects," by Mr Newman, in the *Entomological Magazine*, No. IV. We had not an opportunity of consulting it until our own abstract had been composed, chiefly from foreign sources.

more ethereal essence (language is ransacked in vain for an appropriate term), which can be more immediately acted upon by the mind and will. But this supposed principle, by whatever fond or fantastical name it may be known, whether as a nervous *fluid* or a nervous *power*, has never been detected by the most subtile physiologist, and is known only by its effects. It is, however, undoubtedly the centre from which all power and function flow; and during the absence of worthier substitutes we need not challenge the vague abstractions of some metaphysical inquirers.

The nervous system of insects consists of a homogeneous pulp, usually disposed in twelve successive ganglions, connected by a double cord. We first observe a double or bilobed mass, which, as it is placed in the head, may be called the brain. It is surrounded by strong muscles, and from its anterior portion nerves are distributed to the eyes, antennæ, and mouth. Posteriorly two delicate recurrent nerves proceed towards the dorsal vessel, and inferiorly two larger nerves, after having formed by their branching a kind of ring, which embraces the œsophagus, unite in the form of a ganglion beneath the last-named organ. From the posterior part of this latter ganglion a pair of nervous cords proceed for a space, and then by their union produce a second inferior ganglion, from which the nervous cords again branch off posteriorly, and so uniting and ramifying from space to space, they extend through the different segments of the thorax and abdomen. The number of these ganglia varies; sometimes they correspond to the divisions of the body, while in many instances they are of smaller amount. In the larva of the rhinoceros-beetle, for example, the whole spinal cord (so called from its supposed analogy to the part known by that name among the vertebrate kinds) presents the appearance of a single ganglion, divided merely by transverse furrows,—while in that of a dragon-fly, six have been observed in the thorax, and seven in the abdomen. In the great water-beetle (*Hydrous piceus*) the head exhibits one ganglion, the thorax six, and the abdomen only two. In the honey-bee there are three ganglia in the thorax, and four in the abdomen. When we examine these knots attentively, we may perceive that, in addition to the double and longitudinal nervous cord by which they are connected, they throw off laterally on either side small nervous trunks, which divide into branches, and finally ramify over the muscles, the intestinal canal, the tracheæ, and other parts. This nervous system differs considerably in the larva and perfect insect. In the latter the ganglia are usually less numerous, and the posterior appear formed by the close approximation of several others.

The principal ganglia of the nervous system of insects are frequently thus disposed. The position of the upper or cervical ganglion has been already mentioned. The others rest beneath the intestines, ranging along the inferior face of the body. There are three in what may be called the chest; that is, one in the prothorax, which sends nerves to the anterior legs; one in the mesothorax, which supplies the elytra or the upper wings, and the middle legs; and one in the metathorax, which distributes its filaments to the second pair of wings and the last pair of legs. The other ganglia belong to the abdomen. Insects are characterized by the ganglionic distribution of the nervous system, in common with the Crustacea and Arachnides on the one hand, and with the Vermes or worms on the other. But in insects the ganglia are larger and less numerous than in the still lower tribes, which gives a more decided character of centricity to their nervous system. Indeed the highest manifestation of this character is usually presented only as the ultimate result of several metamorphoses; so that while the larva exhibits a closer agreement with the nervous system of worms, that of the imago or perfect insect assumes a higher development. It does not however appear that the brain or upper ganglion of insects acts in the capacity of a *sensorium commune*, as among warm-blooded animals, such as mammiferous quadrupeds and birds; for many insects will live for a considerable time, and even exercise their faculties of flight, after the loss of parts which among the other class we justly regard as of vital importance. The tenacity of life in horse-flies, for example (*Hippoboscæ*), is very remarkable. When deprived of their heads, and replaced upon a horse, they will be perceived to run backwards and forwards and sideways, with apparently the same ease as prior to their decapitation.[1]

The ganglions themselves frequently exhibit a bilobed structure, which appears to result from the union of two smaller masses, originally distinct. Comparative anatomy tends to confirm this supposition. M. Marcel de Serres[2] maintains that the nervous system of insects, and of all invertebrate animals, corresponds to the eccentric portion of that system among the higher classes, that is, to the intervertebral ganglia and their radiations.[3] In the primitive state of larva he deems the nervous system to consist of two distinct portions, a right and a left; and he maintains that the formation of the nervous system in all animals proceeds from the circumference to the centre, and not, as usually supposed, from the centre to the circumference. We know well, from the observations of Carus and Tiedeman, that the organs of the inferior animals repeat, as it were, the forms which present themselves only in the *embryo* condition of the higher tribes. M. de Serres endeavours to show that it is by the progress of successive developments that the portions of the nervous cord in insects approach each other,—that they first join around the œsophagus, then at the opposite extremity towards the inferior ganglions, and lastly in the central parts. He thus admits three distinct embryo states in the condition of the larvæ; first, that in which the two portions of the nervous system are entirely isolated and distinct; secondly, that in which the œsophagian ganglia are alone united; and, thirdly, that in which the opposite extremities are joined together. By means of this distinctive view, the French physiologist connects the nervous system of insects with that of the Mollusca, the latter presenting the embryo con-

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[1] *Entomological Magazine*, No. iii. 301.

[2] *Ann. des Sciences Nat.* t. iii. p. 377.

[3] The relation which the nervous system of invertebrate animals bears to that of the vertebrated tribes has, however, given rise to many conflicting opinions. "Among the various suggestions on this point, are that of Ackermann and Reil, who viewed the nervous system of Articulata as corresponding to the sympathetic system of vertebral animals;—of Walther, who compared it in the Mollusca to the par vagum, and in the Articulata to the spinal marrow;—the most generally received opinion, however, is that supported by the authority of Meckel, Cuvier, Blumenbach, Gall, and Spurzheim, who compare it in the Articulata to the cerebro-spinal cord of vertebral animals. The latter gentlemen, in particular, have furnished a strong proof of the correctness of this idea, by demonstrating that the spinal cord of the superior animals actually consists of a series of ganglia with intermediate contractions,—a structure most fully developed in the Articulata. Rudolphi (*Physiologie*, b. ii. s. 8, 1823) adopts the same opinion, and notices the fact, that in Mollusca, Crustacea, Insects, &c. we find nerves of sense arising from the cerebral ganglia,—which by no means accords with the character of the sympathetic system." (See Note to Carus's *Comparative Anatomy*, by Gore, vol. i. p. 69.) E. W. Weber (*Anatomia Comparata Nervi Sympathetici*) appears to have been the first to suggest that the ganglia on the knotted spinal cord of articulated animals correspond to the intervertebral ganglia of the spinal nerves of the higher classes, rather than to the segments of which their spinal marrow is composed.

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dition of the former, that is, being permanently distinguished by a characteristic which is only temporary among the articulated tribes. This may probably be regarded as an additional argument in favour of what we shall afterwards endeavour to maintain,—the general superiority in the scale of organization of the annulose classes over the molluscous kinds. We shall conclude by observing, that besides the general protection afforded by the external envelope of insects to their nervous system, it is specially protected by the Y-shaped portion formerly described.

As the nerves constitute the principal media of sensation in all animals, we shall here give a short sketch of the different senses of the insect class.

Of the senses in general, as they exist in man and the higher beings, physiologists and metaphysicians alike enumerate the following *five*, viz. *touch*, *taste*, *smell*, *hearing*, and *sight*. All of these, we doubt not, exist in the class now under consideration, although we are not in every case acquainted with the special organ by which each particular function is exercised.

The sense of *touch* is usually regarded as affording animals, and man especially, a more intimate and assured communication with the external world than those of either sight or hearing, in as far as no intermediate substance comes between us and the subjects of perception. The perfection of the sense depends on the quality of the skin, the extent and nature of its surface, the number of its nerves, its freedom from insensible parts, and the delicacy of those appendages which are more particularly destined to the examination of bodies. As touch is the most important of all the senses, it may naturally be inferred to be finely developed in the human race; and we know that, of all the vertebrated animals, man in that respect is one of the most highly organized. But among the invertebrate kinds the sense of touch improves in proportion as the others degenerate; and those which have no other sense possess it so exquisitely that some of them seem even to *feel the light*.[1]

Among insects the sense of touch varies remarkably according to the condition in which they happen to exist for the time,—their exterior surface, in which the function exists, or at least through which it must be manifested, being itself subject to great variation, even among individuals of the same species. When soft, as in the larva state, the skin is extremely delicate in its perceptions, and capable of transmitting the most lively sensations; while in the imago or perfect condition, more especially among the Coleoptera, its harder consistence renders it chiefly serviceable as a protecting covering. In this case the feet, palpi, and, as many suppose, the antennæ, seem the principal organs of the sense of touch.

The sense of *taste*, which some regard as an exalted modification of the perception of touch, is very obvious among insects. We see many species, while searching after food, reject or only partially consume whatever is disagreeable or unexpected, while they gloat over a more favourite morsel. The organ in which the sense is placed is not, however, so easily determined. Some regard the palpi, and others the pharynx, as its principal seat. That portion of the labium which the French naturalists name the languette or ligula, has also been regarded as exercising the sense of taste. It is certain that distinct nerves are distributed to that quarter, as represented by Lyonnet in his great work on the caterpillar of the cossus.

The sense of *smell* is exquisitely developed in the insect tribes. No sooner has an animal fallen, from age or sickness, even on the loneliest and most barren moor, where perhaps no vestige of insect life was previously perceptible, than troops of flies and carcass-eating beetles assemble from every quarter, led by the emanation of the tainted air.

It was in truth the influence of the sense of smell that in ancient times no doubt gave rise to so many erroneous ideas regarding the origin of insect life. Every animal body in a state of decay being seen to present a crowd of small larvæ or worms, these were regarded as the *produce* of corruption, whereas they resulted naturally, and according to the usual course, from eggs previously deposited by parent flies or beetles, which had been attracted by the putrid effluvia. It is not two hundred years since Redi proved for the first time, by conclusive experiments, that this was true. It is also known that bees will discover and hover around a box containing honey, though their prized treasure is screened from sight; and both flies and beetles are so affected by the perceptions of this sense, that even their peculiar and all but unerring instincts are occasionally deceived by its influence. They will deposit their eggs on plants which are characterized by a fœtid smell (for example, on the *Phallus impudicus*), misled by the resemblance of their flesh-like odour, which the experience of the sense of sight cannot rectify.

The scent of many flowers is cadaverous, and is thus the means of assembling around their deceptive petals numerous insects which feed on putrid matter. It is thus that the spathes of the *Arum dracunculus*, and the corolla of the *Stapelia variegata*, are frequently found covered by Silphæ, flesh-flies, and other species, which not only attempt to feed upon them, but also deposit their eggs in what they conceive to be a fitting station. But the seat of this indispensable faculty is likewise still involved in obscurity. On a subject so difficult of solution, and which can only be solved by a consummate knowledge of anatomical structure, viewed in relation to the uses of physiology, it would not become us to offer an opinion, or do more than report the sentiments of those who are necessarily more experienced than ourselves. Many agree with Dumeril in maintaining that in insects the sense of smell is effected, as among the higher animals, through media in very intimate connection with the process of respiration; in other words, that either the *tracheæ* or stigmatic openings are the seat of its exercise. Others again suppose, that for the exercise of so important a function, a more special and concentrated organ is required; and proceeding upon the analogical relation of mere position, they regard the antennæ as its seat. These receive the first pair of nerves, and so far correspond to the olfactory organs of the higher animals, which are likewise connected with the brain by means of the first pair. The question is one which is extremely difficult of determination, especially in reference to the singular experiments of Huber on bees, which go far to prove that the sense of smell, at least in these hymenopterous species, is placed in the cavity of the mouth.

Christian maintained that insects exercised the sense of smell in relation to distant objects through their antennæ, and in regard to near ones by means of their palpi; while Comparetti imagines that in the different tribes of insects different instruments are subservient to that end. Cuvier, at least in his earlier works (and we are not aware of any recorded change in his sentiments) favoured the opinion already alluded to regarding the respiratory organs. "As the organ of smell," he observes, "in all animals which respire air, is situated at the entrance of the organs of respiration, the most probable conjecture that has been proposed respecting its seat in insects, is that of Baster, since revived by several naturalists, who placed it in the mouths of the tracheæ or air-tubes. In addition to the reasons hitherto stated in support of this opinion, we may observe that the internal membrane of the tracheæ appears very well calculated to perform this office, being soft and moistened, and that the insects in which the tracheæ enlarge, and form numerous or considerable vesicles, are those which seem to possess the most perfect sense of smell. Such are the Scarabæi, flies, bees, &c. The antennæ, which other anatomists have supposed to be the seat of smell in insects, do not appear to us to possess any of the conditions for that organ."[1]

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[1] *Leçons d'Anatomie Comparée*, sect. 14.

Huber's experiments, undertaken with a view to ascertain the seat of smell in bees, consisted in presenting successively to all parts of their bodies a hair pencil dipt in oil of turpentine, an article which they particularly abominate. When made to approximate the head, trunk, or abdomen, it produced no particular effect, and the odour appeared to be equally disregarded by the antennæ and proboscis. But when he brought the point of a fine hair pencil saturated in the oil almost into contact with the cavity of the mouth, above the insertion of the proboscis, the bee started back in an instant, quitted its food, clapped its wings, and would have taken immediate flight had not the pencil been removed. A repetition of the experiment produced the same signs of discomposure; and similar results, but more prompt and sure, followed the use of oil of marjoram. The indefatigable Genevese observer then stopt up the mouths of several bees with paste, which soon became comparatively hard and dry. In this state they were quite insensible to those odours which had previously produced such painful effects.[2]

Mr Kirby maintains an opinion different from any we have yet alluded to, though more allied to the last than to the others. As the nose of an insect evidently corresponds with the part so named in the Mammalia, not only in its situation, but frequently in its form, and as a constant connection may be observed to obtain between the senses of smell and taste, he felt convinced in the first place that the argument from analogy was wholly in favour of the nose, or anterior portion of the head formerly mentioned under that name. The common burying beetle (*Necrophorus vespillo*) is an insect remarkable for its extreme accuracy and acuteness of smell. While examining the nose of this insect, Mr Kirby observed in the middle of its anterior part a subtrapezoidal space, as it were cut out and filled with a paler piece of a softer and more membranous texture. On dividing the head horizontally, he perceived beneath the nose, and partly under the space just mentioned, which he calls the *rhinarium* or nostril piece, a pair of circular pulpy cushions, covered by a membrane transversely striated with beautifully fine lines. These are what our learned author regards as the organs of smell, and he noted that they remained distinctly visible in a specimen which he had had by him for more than fifteen years.[3]

Hearing is perceptibly acute in some insects, and of more doubtful existence in others. The frequent and various sounds to which many species give utterance have been adduced in proof of their being endowed with this perception; for we cannot but suppose that the shrill voice of the grasshopper, and the evening song of the cricket, are subservient to some essential end, which they cannot well be if unheard by their blythe companions. The small wood-devouring beetle called the death-tick (*Anobium*), answers its neighbour's call as regularly as a cock crows a response to its pugnacious rival; and Derham, when he kept these insects in captivity, by imitating their tiny call, could make them click when he pleased. What is called the voice in insects is usually produced by the friction of certain hard and horny parts of the limbs upon some other portion of the body of a like consistence. In others it is effected by a rapid vibration of the wings; and a few beetles seem to give utterance to a shrill and sometimes plaintive cry by rubbing the terminal segments of the abdomen against the curved points of the elytra. This power of voice, as we call it for want of a better name, is often possessed by the males alone; and as it is used as a call of love in spring and summer (most obviously so among the Cicadæ), we infer the sense of hearing in the females of that family, and consequently in the class of insects.

Brunelli kept some large green grasshoppers (*Acrida viridissima*) in confinement. They used to sing all day in a closet, but ceased when any one gave a rap upon the door. He learned by degrees to imitate their chirping call. At first a few of the boldest would answer him, and then gradually the whole band would strike in and sing with all their might. On one occasion he inclosed a male in his garden, and gave the female her liberty; but no sooner did the husband begin to solace his captivity with a song than his quondam partner recognised the accustomed voice, and flew towards him without delay.[4] In relation to this subject Dr Wollaston makes the following curious observation. "Since there is nothing in the constitution of the atmosphere to prevent vibrations much more frequent than any of which we are conscious, we may imagine that animals like the *Grylli*, whose powers appear to commence nearly where ours terminate, may have the faculty of hearing still sharper sounds, which at present we do not know to exist; and that there may be other insects, hearing nothing in common with us, but endued with a power of exciting, and a sense that perceives, vibrations indeed of the same nature as those which constitute our ordinary sounds, but so remote that the animals who perceive them may be said to possess another sense, agreeing with ours solely in the medium by which it is excited, and possibly wholly unaffected by those slower vibrations of which we are sensible."[5]

The precise position, however, of the organ of hearing in insects has not been determined with precision. In the Crustacea it is found at the base of the large antennæ; and Latreille has satisfied himself of its existence in a similar situation in an orthopterous insect called *Gryllus lineola*. Mr Kirby is of opinion that the *primary* use of the antennæ is to exercise a function analogous to that of hearing, and Mr Rennie entertains a similar sentiment.

The sense of *sight* is too obvious in this class to require demonstration. The eyes of insects are, however, of a very different nature and construction from the exquisitely formed visual organs of the higher tribes. They consist of two kinds, the *composite* and the *simple*. The latter, known under a certain form likewise by the name of ocelli or stemmatic eyes (*stemmata*), are sometimes wanting, sometimes co-existent with the others.[6]

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[1] *Comparative Anatomy*, vol. ii. p. 687.

[2] *Nouvelles Observations sur les Abeilles*, t. ii. p. 375.

[3] *Introduction to Entomology*, vol. iv. p. 254.

[4] Lehmann, *De Sensibus Externis Animalium Exsanguium*, 22.

[5] *Phil. Trans.* 1820, p. 314.

[6] What Messrs Kirby and Spence name *conglomerate* eyes do not essentially differ from simple eyes, collected together in a compact bundle. They occur in *Lepisma*, and many Myriapoda.

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The composite eyes generally form, as it were, the lateral portions of the head. They are either entire, notched, or even occasionally so completely divided by a little corneous stalk, as to exhibit (for example in the genus *Gyrinus*) the appearance of a pair on either side. In other respects their forms are extremely variable—their surfaces more or less convex. These compound eyes are composed externally of a hard and transparent membrane (softer in the dipterous tribes), which presents an infinity of small hexagonal surfaces, disposed with the most exquisite regularity. This peculiar structure prevails equally on the concave or internal, as on the convex or external surface. The structure and composition of the eyes of insects have been carefully studied and explained by Leeuwenhoeck, Swammerdam, Cuvier, and more lately and laboriously by Marcel de Serres. We shall here avail ourselves of the *resumé* given by M. Victor Audouin.[1] In the eye of an insect we observe, 1*st*, a cornea (convex in proportion to the carnivorous habits of the species), transparent, hard, thickish, generally encased in a groove of the head, and exhibiting many thousand regularly disposed, hexagonal facettes, each of which is in itself a perfect eye. These are sometimes so numerous that not fewer than 34,650 lenses have been counted in the head of a butterfly, and the coleopterous genus *Dynastes* of Macleay is supposed to be still more wonderfully and exuberantly supplied. 2*d*, An opaque, slightly liquid matter, variously coloured, frequently deep violet or black, but sometimes red or green, tenaciously adherent to the inner face of the cornea, and distinct from the deep-black varnish of the choroid. It is by no means rare to observe various colours united in the same eye, which then appears beautifully mottled, as in many species of the orthopterous, neuropterous, and dipterous orders. These tints, however brilliant in the living state, speedily vanish after death. They are always owing to this peculiar coating of the cornea. 3*d*, A true choroid, covered by a dark varnish, which may be regarded as a *pigmentum nigrum*. The lynx-eyed Swammerdam failed to distinguish this coating from that of the cornea; but, in the opinion of Marcel de Serres, it is really different. The choroid and its pigment do not always exist in insects. They are wanting in the *Blattæ*, and in all the lucifugous or light shunning species, such as those of the genera *Blaps*, *Tenebrio*, and *Pedinus*. In these cases, it has been remarked that the covering of the cornea is much deeper than usual. The choroid membrane is fixed by its circumference to all the margin of the cornea, of which it follows the contour, and is intimately connected with the tracheæ, which are there so numerous. 4*th*, Air vessels which play an important part. They take their rise from larger trunks which are situated in the head, and form around the eye a circular trachea, which sends forth an infinity of branches, producing by bifurcation a number of isosceles triangles. These triangles, of which the base is outwards, are placed around the optic cone, and receive, in each angular interval which separates their summits, a nervous filament, which traverses the choroid, and reaches the external surface of the covering of the cornea. The assemblage of tracheæ and nervous threads forms at the circumference of the eye a peculiar kind of network, of which the aspect is beautiful to look upon. The tracheæ themselves are so abundant on the choroid, that that membrane appears to be composed of them; and it may also be noted, that in those genera in which the choroid is wanting, the circular trachea is likewise absent.[2] 5*th*, Nerves arise from a principal branch which, after proceeding immediately from the brain (or upper ganglion), is either encompassed by a little circular trachea, or traverses the fibres of the abductor muscle of the mandibles. This branch soon augments in volume, and forms a kind of cone more or less extended, of which the base is towards the transparent cornea. Numerous nerves proceed from that base, mingle with the tracheæ of the choroid, traverse both that membrane and its pigment, penetrate the lining of the cornea, and finally terminate each on a facette of the transparent cornea, so that the nervous filaments are thus immediately in contact with the light, which reaches them after having traversed only the last-named organ. This disposition of the nervous threads, which thus constitute as many small retinæ as there are facettes in the cornea of the eye, is very distinguishable in *Libellula*, *Truxalis*, and *Gryllus*. The eyes of insects, then, contain no humours properly so called,—neither vitreous nor crystalline,—and vision is consequently much more simple with them than with the vertebrated tribes, in which the nerves are placed deeper in the eye, and do not receive the rays of light till these have passed through media of different densities.

The simple or *stemmatic eyes* of insects are usually three in number, and are placed on the crown of the head, between the genuine organs of sight, from which their structure differs. In spite of their extreme minuteness, Marcel de Serres has succeeded in detecting the following component parts. 1*st*, A transparent cornea, formed by an external membrane, hard, convex externally, and smooth, that is, exhibiting no appearance of facettes. 2*d*, Of a variously-coloured matter, which lines the internal face of the cornea, but which is perhaps not essentially distinct from the varnish of the choroid. It varies in colour, being almost always black in Hymenoptera, usually whitish in Orthoptera, and, in many caterpillars, yellow, red, or green. 3*d*, A kind of choroid, rather thick, more extended on the surface than the cornea itself, sometimes of a black colour, more frequently red, and occasionally of a peculiar whitish hue. 4*th*, Tracheæ, which do not derive their origin from a circular air vessel, and do not, as it were, constitute the choroid, but appear to be distributed over its surface. 5*th*, Nerves proceeding either directly from the brain or upper ganglion, or from another more considerable nerve or common trunk, according as these simple eyes are separate from each other, as in perfect insects, or closely approached, as among larvæ. In their passage towards the eyes they are attached to the neighbouring parts by tracheæ or air vesicles, and do not appear to present any swelling; they pass between the motive muscles of the different parts of the head, traverse the choroid and its varnish, and expand upon the internal face of the cornea, where they are surrounded by the layer of pigment belonging to that membrane. Thus, on examining the simple or stemmatic eyes of insects, and proceeding from the circumference to the centre, we meet with a transparent cornea,—a pigment, which lines its inner face,—the termination of the optic nerves,—the pigment of the choroid, when distinct from that of the cornea,—and the choroid itself, which frequently rests upon a large trachea. The principal character of these simple eyes consists in this, that each is a single organ, whereas the composite eyes, as the name implies, are formed by the union of many. The one kind is most characteristic of the larva state, the other of the perfect insect; but several orders, even in the last-mentioned condition, possess both organs.

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[1] *Dict. Class. d'Hist. Nat.* t. viii. p. 554.

[2] Muller and others appear to entertain a different view from that given above. The subject is one of considerable complexity, and our present limits prevent our entering into its various and sometimes contradictory details. We refer the curious reader to a series of papers on the visual organs of insects and Crustacea in the fourth volume of the *Naturalist's Magazine*.

Thus, with few exceptions, the Orthoptera, Hemiptera, Hymenoptera, Neuroptera, and Diptera, possess both simple and compound eyes. Dr Carus however states that the stemmata do not exist either in beetles or butterflies; a most erroneous opinion in regard to the latter, in which they exist universally, although not always detected; and incorrect as to the former, in several of which they have been distinctly seen. They are visible in Gravenhorst's genus *Omalium*, or at least in some of the species;[1] and Mr Kirby found them very conspicuous in *A. Caraboides*, and other Anthophagi. They are wanting in Strepsiptera, Dermaptera, and Aptera.

Although neither Linnæus nor Fabricius, those great masters in the science, gave any explanation of the uses of the stemmata, there can be no doubt that Swammerdam and Réaumur were correct in regarding them as genuine eyes.[2] The French writer supposes that the compound organs have the power of magnifying, and are used for surveying more distant objects, while the simple ones possess little of that power, and are employed on objects close at hand. Blumenbach is also of opinion that the polyhedral eyes are for viewing distant objects, and the simple ones for such as are near.[3] This is in some measure confirmed by the fact, that while most insects in the perfect state have large compound eyes, caterpillars and other larvæ have usually small myopic ones. On the other hand, the Mole cricket (*Gryllotalpa*), a truly subterranean species, is furnished with both kinds. Réaumur's experiments on the visual organs of bees are extremely important in relation to our present subject. He smeared the compound eyes with paint, when the insects, instead of directing their flight towards the hive, ascended in the air till they were lost to sight. He then treated the stemmatic eyes in the same manner, and placing his patients near their hive, they winged their way on all sides among the surrounding flowers, but neither ascended into the air, nor flew far from home. From these experiments it has been supposed that the compound eyes are for horizontal sight, and the stemmatic for vertical.[4] Spix imagines that what we call simple eyes in insects are in fact olfactory organs.[5] Nothing can be adduced in support of a theory so fantastical.

We shall conclude this branch of our subject by observing that some insects are supposed to be entirely destitute of eyes. This is the case, according to Rudolphi,[6] with the coleopterous genus *Claviger*, in which there are certainly no apparent eyes; and Marcel de Serres observes, "un assez grand nombre de larves à metamorphose complète n'ont point d'yeux du tout."[7]

SECT. II.—THE RESPIRATORY SYSTEM IN INSECTS.

Though insects respire air, they do not receive it, like the majority of vertebrated animals, through nostrils or other orifices in the head, but by means of numerous small openings along the sides of the body, and which lead not to lungs, but to a system of air vessels ramified *ad infinitum* through every part of the body. The respiratory organs of this class are composed of *stigmata*, *tracheæ*, and *bronchiæ*. The first, called also spiracles or breathing pores, consist of small perforations of various forms, placed along the lateral portions of the body, and generally incased externally in a small corneous ring, though sometimes pierced in the membrane which separates the dorsal from the ventral surface. These stigmatic openings occur both on the thorax and abdomen, and lead inwards to the tracheæ. Their number varies according to the species, and even in the same species according to the temporary condition of the individual. They are wanting on the second and third segments of the body of the larva; and as it is from these segments that the wings are developed, M. de Blainville has been induced, probably by that circumstance, to regard the organs of flight as reversed and expanded tracheæ. The existence, however, of stigmatic openings on the thorax of the perfect insect simultaneously with the wings, militates against this theory; for if these parts were convertible, would they not be likewise each exclusive of the other?

Parallel with the sides of the body of most insects, and extending its whole length, run two cylindrical tubes, which communicate with the spiracles, and give issue, at points opposite to those organs, to other tubes, the ramifications of which are distributed over all the membranes, penetrate the muscles, and pervade even the legs and wings. They also envelope the dorsal vessel and digestive organs, and demonstrate that the ultimate aim of respiration is assimilation, or the increase and reproduction of organic molecules, by the decomposition of food. The first of these tubes are called the tracheæ, the latter the bronchiæ. This structure, however, cannot be regarded as universal, as in many of the lamellicorn beetles the bronchiæ spring directly from the spiracles, the interior mouth of which is lined by a membrane from which they proceed.[8] But a volume would scarcely suffice to describe the beautifully varied features of the respiratory system in insects. Among those tribes especially which pass their early stages under water, the changes in form and position in these organs cannot be sufficiently admired. Several common species of gnat, the larvæ of which abound during the summer season in all our ponds and marshes, will afford a familiar illustration. When one of these is examined, a singular tunnel-shaped organ, terminating in a radiated point like a star, will be perceived, forming an angle with the penultimate segment of the body. In the interior of this organ is a tube, which conveys the air to the tracheæ, and communicates with the atmosphere by means of several perforations in the centre of the star. The diverging rays of the star suspend the animal at the surface of the water, with its head downwards, till it wishes to descend. It has no sooner assumed the pupa state, than the respiratory tail disappears, and the insect (still an inhabitant of the water) then breathes through two projecting horns, each resembling a little cornucopia, which proceed from the upper part of the trunk. Ere long the skin of the pupa bursts asunder, and the perfect gnat, or winged insect, makes its appearance, with neither caudal nor thoracic appendages, but breathing by means of numerous lateral pores (the stigmata above mentioned), after the usual manner. The *rat-tailed worm* in this respect is still more extraordinary. In the larva state it breathes through a tail formed of retractile tubes, like a telescope, and capable of being extended many times the length of the body. This also terminates in a star-like process, which, when viewed in a strong light, forms a perceptible dimple on the surface of the water; and as the body of the insect lies in the mud below, the tail is contracted or extended according to the varying depth of its stagnant habitation. On assuming the pupa state, in which it is no longer an aquatic animal, the respiratory tail is cast off, and its function performed by four horns, which spring from the upper part of the thorax. It afterwards becomes one of those bee-like flies so remarkable for the rapid vibratory movement of their wings, by which, during calm sunshine, they are often seen suspended in the air like hawks, without any perceptible motion. In this last stage respiration is carried on by spiracles or breathing-pores.

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[1] *Magazin der Entomologie*, iv. 410.

[2] See *Biblia Naturæ*, i. 214; and *Memoires*, iv. 245.

[3] *Vergl. Anatomie*, p. 425.

[4] *Introduction to Entomology*, iii. 505.

[5] *Cephalogenesis*, p. 57.

[6] *Physiologie*, ii. 154.

[7] *Mem. sur les Yeux composés et les Yeux lisses*

[8] *Introd. to Ent.* vol. iv. p. 61.

SECT. III.—THE DORSAL VESSEL, OR SUPPOSED CIRCULATING SYSTEM, OF INSECTS.

We shall next endeavour to explain the construction and physiological uses of the organ known by the name of *dorsal vessel*.

The *primary* use of the heart of animals is the elaboration of the nutritive fluid by which the general system is strengthened and sustained; its *secondary* use is to effect the circulation of that fluid, a process by which important changes are produced in its nature or attributes. The dorsal vessel, which corresponds to the heart in insects, certainly effects the primary purpose; its performance of the secondary one is, as we shall see, a matter of greater dubiety.

When an insect is dissected with due precaution from its inferior surface, and we remove the nervous system, which first presents itself, and then the intestines and other viscera, we shall observe running along the back, a peculiar vessel, of which the most obvious powers are those of contraction and dilatation. It is of a cylindrical form, narrowed at either end, and extends from the head to the anal extremity. This constitutes the *heart*, frequently so called, of the class of insects. A closer examination shows that it is composed of two membranes, one internal and muscular, the other external and cellular, and pervaded by a close interlacement of tracheæ or air-vessels. When opened, its interior presents a transparent coagulable liquid, which dries rapidly, and then exhibits the aspect of gum, of a colour seldom deeply defined, but sometimes greenish, orange yellow, or sombre brown. Masses of fat frequently surround this vessel, and partake of the tint by which it is pervaded. If, as Marcel de Serres has noted, the *dorsal vessel* (for so this organ is often named) were a genuine heart, or centre of a circulating system, it would be necessarily open at one or other of its extremities, and would present vascular ramifications in certain points of its extent. But, according to the minute and laborious investigations of the last-named author, no such openings are observable. The same view was taken by Swammerdam; and Lyonnet, so unrivalled in his examination of the structure of insects, was foiled in his attempts to demonstrate the ramifications of the dorsal vessel. Comparetti no doubt took another view of the subject; and if the assurance of his readers was equal to his own, less suspicion would exist of the possibility of his having mistaken biliary for sanguineous vessels.

Anatomists, however, are greatly divided in opinion regarding the essential nature of this organ. It has been dissected and injected by Marcel de Serres in a variety of species; but in none could he discover its divisions or ramifications. Even when he removed it entirely from the insect, no drop of the liquid which it contained was observed to escape, which he thinks it must have done on the cutting away of open vessels during dissection, had these existed. The *beating* of this dorsal vessel was not explicable, otherwise than by the contraction of its tissue, or the movement of the fluid which it contained; and such movement was not itself conceivable except in the case of circulation, which the alleged closure and non-division of the organ forbade us to suppose. Its contractions also appeared irregular, and scarcely ever isochronic; that is, the same number of pulsations, if they may be so called, did not take place in an equal time. They varied singularly in different species. Thirty-six per minute were counted in the caterpillar of the *Pavonia Major*, eighty-two at least in grasshoppers, and a hundred and forty in one of the ground bees. While endeavouring to discover the cause of these contractions, Marcel de Serres came to the conclusion that they bore a relation, 1*st*, to the quantity of adipose tissue by which they were surrounded; 2*dly*, to the energy of the muscular fibres which were inserted on the vessel, and were the means of fixing it to the rings of the abdomen; 3*dly*, to the number of tracheæ or air conduits by which it was supplied. He was not of opinion that the nerves exercised any strongly marked influence on these contractions, although we know that special nerves are directed to the dorsal vessel. The fact, however, which he deemed the most clearly established, was the influential action of the muscles. When any of these were removed, the pulsations became less frequent,—on a farther removal they still diminished; and when the muscles were almost all withdrawn, the pulsations ceased. The appropriate function of this disputed organ, according to the last-named author, is the secretion of fat. Baron Cuvier also denies to it the character of a genuine heart.

Meckel and Herold, on the other hand, regard the dorsal vessel as a heart, and they conceive that the use of its movement is to agitate the fluid contained in the cavity of the insect's body; but they do not admit the existence of posterior or anterior openings for the reception or rejection of that fluid. It is long since Lyonnet informed us that it contained a gummy matter of an orange colour; and some recent observations have led Latreille to admit the existence of certain very minute accessory vessels. In addition, however, to the fact that this circulation must be extremely partial, insects would still greatly differ in that respect from the Crustacea, inasmuch as the blood does not return to the heart. Herold is of opinion that the triangular muscles of the dorsal vessel serve for its dilatation, while the systole movements are effected by the muscular fibres, which form the proper tunic. Straus is also of opinion that the dorsal vessel is the true heart in the class of insects, and that it serves, as in the higher animals, as the motive organ of the blood, which, however, instead of being contained in vessels, permeates in the general cavity of the body. According to his views, it terminates anteriorly by a single unramified artery, which conveys the blood to the head, where it pours it out, and from whence it returns again to the abdomen, to re-enter the dorsal vessel. He thus limits the circulating system of insects to a single artery without branches (there are not any veins); and he combats the sentiments of Herold regarding the muscular nature of the wings of the heart, which, he maintains, are only simple fibrous ligaments, by which it is maintained in its proper place. The heart itself, that is, the abdominal portion of the vessel, he describes as divided interiorly into eight successive chambers (as in the common cockchafer, *Melolontha vulgaris*), separated from each other by two convergent valvules, which permit the transmission of the blood or circulating fluid from behind forwards, and from one chamber to another, up to the artery which conducts it to the head, but prevent its retrograde motion. Towards the lateral and anterior portion of each chamber are two transverse fissures, which communicate with the abdominal cavity, and through which the blood contained in the latter enters the heart. Each of these apertures is provided internally with a little semicircular valve, which presses on it during the systole of the organ. When the posterior chamber dilates, the fluid contained in the abdominal cavity penetrates into it by the transverse fissures, called *auriculo-ventriculaires* by M. Straus. When the chamber contracts, the blood, unable to return into the abdominal cavity, forces the *inter*-ventricular valve, and passes into the second chamber, which dilates to receive it,

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along with an additional quantity which enters by the true auriculo-ventricular openings. The second chamber then contracts in a similar manner, and forces the fluid into the third, which at the same time also receives a supply from the lateral openings; and thus the blood is forced from one chamber to another by successive contractions, till it reaches the artery. These are said to constitute the movements so distinctly perceptible through the dorsal skin of many caterpillars.

Mr Bowerbank has recently published some observations on the circulation of the blood in insects.[1] The instance detailed was that of the larva of an Ephemera (*E. marginata*). In fixing the insect for examination (under water), especial care must be taken not to compress the body, which impedes or interrupts the circulation of the lateral vessels, and that of the tail, legs, and antennæ. When the larva is fixed, with its dorsal aspect towards the observer, a truly beautiful sight is said to present itself. The blood, abounding in flattened oat-shaped particles, will be seen circulating in every part of the body, not in a continuous stream, but at regular points, in accordance with the pulsations of the great dorsal vessel. The latter, which is of great comparative magnitude, extends nearly the whole length of the body, and is furnished at regular intervals with double valves, nearly equal in amount to the segments of the body. Both above and below each of these sets of valves there is a pair of irregular-looking appendages, which are probably nervous ganglions, auxiliary to the motions of the vessel, but so extremely translucent as to be scarcely definable in their form, even through the medium of the highest power which we can apply. The action of the valves is singularly interesting. While in their greatest state of collapse, the point of the lower valve is seen closely compressed within the upper one. At the commencement of the expansion of the artery, the blood is seen flowing in from the lateral aperture, and at the same time the stream in the artery commences its ascent. When it has nearly attained its greatest state of expansion, the sides of the lower valve are forced upwards by the increased flow of the blood from the section below the valve, the lateral openings are closed, and the main current of the blood is projected through the two valves. The structure of the upper valve appears to consist of a duplication inwards and upwards of the inner coat of the artery; that of the under, of a contraction and projection of the like parts of a portion of the artery beneath, so as to come within the grasp of the lower part of the valve above it. The exterior portion or continuation of the artery is perceptible in the form of an exceedingly fine and transparent membrane. The so-called blood does not appear to be confined within any specific vessels prior to its entering the lateral openings just mentioned, because, as soon as they expand, the particles are seen converging towards them. The whole of the fluid received throughout the course of the dorsal vessel is conveyed to the extremity of the anterior part of the body, where the vessel makes a curve inwards, and is lost to view. To all appearance the main current of the blood is now discharged into the cavity of the body, as it is seen pursuing its course downwards in a wide-spreading stream on each side, and beneath the dorsal vessel. As it descends, portions are again absorbed by the valves of the large vessel, while at the same time smaller vessels pass down each side of the body, and convey another portion of blood to the lower extremity. These lesser vessels have perceptible boundaries, and are certainly not portions of the great abdominal cavity. They communicate at each junction of the segments of the body with that cavity, as a part of the fluid they convey is discharged at those points, to supply the place of what is absorbed by the valves of the dorsal vessel, into the lower end of which they empty their contents. In the caudal extremity the ascending and descending vessels are seen, like vein and artery, to accompany each other, and at the same moment that the fluid passes up the one with the usual pulsatory motion, it descends the other. There is, however, no perceptible pulsation of these minuter vessels themselves, and the motion of their fluids therefore results from the action of the great dorsal heart.

"Next to the larvæ of the Ephemera marginata," Mr Bowerbank observes, "the larvæ of Agrion afford the best view of the blood and its circulation. In all the species of these larvæ I have yet examined, I have found it as nearly similar as possible in appearance to that which we observe in the Ephemera, and in some instances it has afforded even more satisfactory results. The head of this larva is much more transparent than that of the larva of the Ephemera; we therefore have a better view of the circulation of the blood in the head of this insect than can possibly be obtained in the other. In this object the blood is seen rushing like a beautiful intermittent fountain towards the mouth, and dividing right and left into two jets, a portion of each of which flows within a given boundary past the back of the eye, whilst the remainder winds its way through other channels, deep in the side of the head, and returns again into the body. The antennæ of this insect also afford another beautiful instance of the circulation being carried forward within well-defined vessels. They are each composed of six joints, up four of which the blood is seen to take its course; and turning round the extremity of the fourth joint, it returns by a distinct vessel into the head. In the leg, likewise, the circulating fluid and its vessels are clearly and distinctly to be traced, even to the very extremity of the tarsus, where, as in the antennæ, the particles of the blood are seen to descend on the one side of the leg, and, turning the extreme point, to return up the contrary side to the one by which they come down. I regret much that I have not yet had an opportunity of examining the Ephemera in its perfect state; but in two species of Culex, one of which was first observed and brought to me by my friend Mr Tulley, I have seen the great dorsal vessel performing its functions in a manner similar in every respect to its appearance in the larvæ of Ephemera, Agrion, &c. &c.; but, from the body of the fly being more opaque than that of the larvæ, and nearly covered with its striated scales, neither the valves nor the particles of the blood could be detected. On another occasion, after having carefully cleared the wings of Phlogophora meticulosa of their coloured scales, both Mr Samouelle and myself clearly saw a fluid pass down the side of one of the principal ribs of the wing. We may therefore, I think, fairly conclude, that the circulation is carried forward in the perfect insect as well as in the larva, although, perhaps, not with so much vigour as when young and growing."[2]

The writer whose observations we have just quoted, inclines to the opinion that a much greater portion of the circulation than we can clearly define is carried on within special vessels, as the blood may be frequently seen flowing in curved and other lines, as if confined within very narrow limits. These streams, however, are generally so deeply seated amidst the muscles and intestines as totally to prevent their boundaries from being clearly seen. The blood itself is in fact a perfectly colourless and transparent fluid, rendered visible only by its containing a number of oat-shaped particles; and even the great dorsal vessel cannot be seen distinctly but by means of a glass of great power, and, under the most favourable circumstances, exhibits defined limits with certainty only when in motion. A singular coincidence is observable between the flattened particles of the blood of insects, and the circular double concave plates in that of man, namely, that the former, in common with the latter, assume a globular form immediately on coming into contact with water.[1]

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[1] *Entomological Magazine*, No. III. p. 239.

[2] *Ibid.* p. 242.

The reader will be able to judge, from the preceding notices, of the diversified opinions still entertained regarding the circulation of the blood in insects. We shall conclude with a short account of Dr Carus's observations, which many consider as the first of a satisfactory and conclusive nature on the subject. Mr Spence, the accomplished coadjutor of Mr Kirby, having had the advantage, at a pretty recent period, of witnessing some of the most striking facts on which the Dresden physician rests his views, transmitted an account of them to an English periodical. "The first insect," he observes, "to which Dr Carus directed my attention was the larva of *Ephemera vulgata* (or an allied species), in which, near to the branchiæ, and parallel with each side of the body, was very distinctly visible a constant current, towards the tail, of oblong globules, swimming in a transparent fluid, propelled with a regular pulsating motion; and in cutting the body of the larva across, near the tail, these globules were most plainly seen pushed out of the divided vessels in a distinct mass, which increased at each pulsation. I cannot express the pleasure which it gave me to see thus clearly this ocular demonstration of one of the most important physiological discoveries of modern times; and my gratification was heightened by the next object which Dr Carus placed before his microscope, viz. a specimen of *Semblis viridis*, in which precisely the same phenomena, but if possible more clearly, were seen in the nervures of the wings, and in the antennæ, in both which the constant current of globules was most apparent; and in the former, the sudden turning of these globules at the apex of the wing, out of the exterior nervure, into a central one, with which it joins and forms an acute angle, was equally curious and striking. On cutting off the end of the antennæ, precisely the same emission of globules (which soon assume a greenish tint) took place as in the former case, forming a mass which was increased with a sudden gush at each pulsation."[2] The chief point to be attended to in the manipulation of these microscopic experiments, is to place the specimens on the slip of glass, in a drop of pretty thick gum water, which confines their too agile movements, without affecting the transparency of the medium.

SECT. IV.—OF THE ADIPOSE TISSUE OF INSECTS.

Insects are abundantly supplied with an adipose substance or fatty matter, which may be mentioned in this place with the more propriety, as many consider it a secretion from the dorsal vessel. It is spread over the viscera and in the splanchnic cavities; and although its aspect varies, it seems to consist essentially of membranous woofs, in some cases divided in shreds, in others spread over the intestines and against the sides of the abdomen, and containing pouches filled with a homogeneous pulpy matter, sometimes in an oily condition, and offering all the characters of grease. Much more of it is observable among larvæ than in perfect insects, and this observation leads us to a knowledge of its use. It is particularly plentiful just before an insect is about to undergo its metamorphosis; and as it almost entirely disappears on the completion of those signal changes, we naturally conclude that it has served in the production or development of the newly acquired organs. This is rendered the more probable when we consider that, during the intermediate or nympha state, the insect abstains from food, and is therefore necessarily dependent on some internal reservoir. It is analogous, in fact, to the store of fat which is known to pervade the system of hybernating animals before they consign themselves to their winter sleep.

In regard to the nutrition of insects, our opinions must be in a measure regulated by the sentiments which we may adopt as to the functional uses of the dorsal vessel. We need scarcely observe, that in all the higher animals, and in most of the invertebrated tribes, nutrition is effected through the medium of the blood, which, propelled by the heart, circulates through the entire system, and reaches every organ, after having been submitted to the action of the air in lungs or gills. Cuvier thinks it is carried on among insects by imbibition. The alimentary canal elaborates a fluid which transudes through its coats, and flows into the cavity of the body. There the various organs, such as the muscles, the nerves, and many secreting vessels, absorb from that fluid nutriment, whatever molecules are best adapted to their purposes. Those who look upon the dorsal vessel as a true heart, which dispenses a circulating fluid to the remotest ramifications of the wings and tarsi, will place less confidence in this particular view. However, it is certain that the secreting vessels are characterized by a structure entirely appropriate to the functions which we have just assigned them, their surface being obviously furnished with numerous pores or small absorbent mouths.

SECT. V.—THE DIGESTIVE SYSTEM OF INSECTS.

The digestive system in insects naturally forms the next subject of consideration. The earliest, most general, and perhaps the only indispensable function of animal life, is that of nutrition. But its materials are so different, and their modes of reception so various, that the exercise of this function by no means necessitates the existence of a mouth, a stomach, or an alimentary canal; for an increase of parts may be effected even through the medium of imponderable or elastic fluids, and by imperceptible and superficial pores.[3] The digestive organs of insects are however in general rather complicated, and a great variety of parts are brought into action. The more external portions, or those of the mouth, have been already described. We shall therefore at present confine our observations to the different portions of the *intestinal canal*, and the *biliary* and *salivary vessels*.

It is natural to suppose that, in a class so extensive and varied as that with which we are now engaged, a corresponding diversity must exist in the form, development, and number of the parts which constitute the intestinal canal. It is always, however, so far tubular, and open at either end; but in some it is straight and of the length of the body; in others it is bent and longer than the body; while in many it is tortuous, or twisted on itself in numerous convolutions, and consequently of great extent. In general, its length corresponds in a certain measure with the nature

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[1] *Entomological Magazine*, p. 244.

[2] *Magazine of Natural History*, vol. iii. p. 46. See also the German memoir by Dr Carus on the circulation of the larvæ of neuropterous insects (Leipsig, 1827). The English reader may consult Mr Gore's translation of Carus's *Introduction to Comparative Anatomy*, appendix to vol. ii. p. 392.

[3] Vol. iii. of this work, p. 183.

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of the aliments; such insects as feed on vegetable matters having a longer, and such as feed on animal substances a shorter canal. In some it is of equal diameter throughout; in others the breadth of special portions varies; and there are many dilatations and restrictions, known by various names. It even differs greatly in the same species, according as the individual exists in the larva or imago state.

The texture of the intestinal canal in insects is not the same in all parts of its extent; but on a careful examination it is found to exhibit throughout three tunics, more or less distinctly marked. Of these, the first is external, with a membranous aspect; the second is of course intermediate and muscular, with its fibres diversely directed; the third is internal and mucous. In its more complicated state it exhibits the following parts: 1*st*, a *pharynx*; 2*d*, an *œsophagus*; 3*d*, a *crop*; 4*th*, a *gizzard*; 5*th*, a *chylific ventricle*; 6*th*, *intestines*, which may be considered in subdivision as the small intestines, the great intestine or cæcum, and the rectum. The following may be regarded as the usual process of transmission. The mouth, having seized and chewed the food, transmits it to the pharynx, into which salivary vessels sometimes open. It then passes into the œsophagus (of which the muscular nature occasionally produces by its action a peculiar impression), and is next transmitted to the crop, which converts it into a homogeneous pulp. This is introduced into the gizzard, of which the sides, being armed with teeth, complete its trituration. In the form of a kind of paste it is now received by the chylific ventricle, where it undergoes the action of the bile, is converted into chyle, and thus supplies the nutritive fluid, which, passing through the coats of the ventricle, spreads over the splanchnic cavity, and pervades the whole of the organs. The residue is received by the small intestine, then by the great intestine, in which it remains for some time, and finally by the rectum.

The *pharynx*, which is sometimes rather difficult to distinguish as a distinct feature, is placed at the bottom of the mouth, and may be regarded as an anterior dilatation of the œsophagus. Two pieces, very apparent in certain Hymenoptera, called the *epipharynx* and the *hypopharynx*, seem to restrict and protect its entrance.

The *œsophagus* is a conduit varying in length, which traverses the prothorax, and sometimes extends beyond it; but it is occasionally so short as scarcely to pass beyond the region of the head. Its structure is musculo-membranous, and it opens into the crop, or, if that part is wanting, into the gizzard, or, if the latter is also absent, into the chylific ventricle. It is around the origin of the œsophagus that the nervous system, as formerly described, constitutes a ring, by sending forth two branches which unite on the inferior face of the body.

The *crop*, which is by some called the stomach, is essentially nothing more than a dilatation of the œsophagus. It is often difficult to detect, is sometimes entirely wanting, and may be observed to vary greatly even in two individuals of the same species. Exteriorly it does not differ much from the gizzard, but its interior never presents those corneous pieces which in the latter serve the purposes of trituration. Its position bears some analogy to that of the crop of birds, from which circumstance it has probably derived its name. Its texture is simply membranous, or slightly muscular when its development is considerable, and in that case it is not rare to observe certain folds or fleshy columns and deeper lines, which give it something of a ribbed appearance. These folds, prolonged in the interior, frequently constitute a kind of valve. It is in this crop that bees contain their honey prior to their disgorging it, and it likewise serves as the reservoir of that black and often fetid fluid which many insects allow to flow from their mouths when they are seized. The form of the crop differs in the various species; and even in individuals of the same species, according to its state of repletion or vacuity, it assumes an ovoid, rounded, or pear-shaped appearance. In some orders of insects it is greatly developed, and very muscular; and in certain cases, instead of lying in the same direction with the intestinal canal, it forms with it an angle more or less acute, thus constituting a lateral pouch varying in extent and form.

The *gizzard* follows the crop. Its existence is not constant, and its essential character consists in its singular internal structure, which is furnished with moveable portions of a horny texture, provided with ridges or bristles pointed in all directions, in the form of combs or brushes. The principal portions are more or less numerous, and form by their union a kind of valvule at the orifice of the chylific ventricle, into which they permit nothing to enter but what has been previously reduced to a state of tenuity. This very singular triturating machine, as we may call it, exists among both the herbivorous and carnivorous kinds. It recalls to mind the aspect of the stomach among the crustaceous tribes. Externally it greatly resembles the crop, and indeed can scarcely be distinguished from it otherwise than by its internal structure.

The *chylific ventricle*, which corresponds to the part named *duodenum* by Marcel de Serres, and *stomach* by Ramdhor, is a very constant organ among insects, although its form and character are extremely various. It is here that the pulpy food, mixed with specially elaborated fluids, is converted into chyle. One of its most constant characters is the insertion on a kind of circular pad more or less developed, of at least one extremity of the biliary vessels. Its texture is soft and delicate, and capable of varying its capacity by extension. Its form is generally cylindrical, although it sometimes undergoes dilatations and restrictions in its course. In some rare instances, detailed by M. Dufour, it is bilobed or bifurcated at its commencement, the preceding part of the alimentary canal being inserted in the angle of the furcation. It presents several other occasional and very curious characters, but it is in general straight, and but rarely exhibits a limited number of convolutions. It is not garnished interiorly with triturating organs, either muscular or corneous; but it is furnished with a valvule at the point of union with the intestine. One of its most curious characters consists in its being sometimes villous on the surface, that is, covered by a quantity of little tubes, named *villosities* by Cuvier, and *papillæ* by Dufour. These are a species of tubes or purses, somewhat resembling the fingers of a glove, and opening into the ventricle. Their functional uses are differently construed by physiologists. Cuvier inclines to think that they draw from the abdominal cavity a gastric fluid, which they pour into the ventricle to aid digestion. Marcel de Serres partakes of the same opinion, and regards these papillæ as the superior hepatic vessels. Dufour, however, does not consider them as analogous to the biliary vessels, but as culs-de-sac, which receive the alimentary fluid, and, after its conversion into chyle, transmit it to the abdominal cavity. That able anatomist has recognised in their interior a brownish matter, quite analogous to what is contained in the ventricle itself. They do not differ greatly as to form, but a great variation occurs in regard to number and disposition. Sometimes they exist in great numbers throughout the whole extent of the ventricle, sometimes they are fewer in number, and confined to a limited portion. Insects belonging to the orthopterous order have but few of these papillæ, but they are greatly developed, and inserted on the anterior part. In other instances the papillæ are entirely absent; and the ventricle is then smooth, or occasionally exhibits depressed lines, which divide it transversely into so many little bands. The presence of

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these papillæ cannot be regarded as a constant character in any group, for we find them absent or present in different insects of the same family, without any known or assignable cause. They occur indiscriminately among carnivorous and herbivorous species; but it is among the coleopterous tribes that they show themselves most frequently, and under the most characteristic forms.

The *intestines* constitute an extended portion of the canal. They receive the alimentary matters after they have been digested in the chylific ventricle, and extract by their action whatever nutriment remains. Their absorbent powers, however, as alimentary organs, are probably confined chiefly to their upper portion. They consist of a *small intestine*, a *great intestine*, and a *rectum*. The small intestine of course proceeds from the ventricle, and is in general narrow, with an equal diameter throughout, although it is sometimes swollen or pursed in the course of its extent. It is of various length, and makes numerous circumvolutions in the interior of the abdomen, after which it borders with the great intestine. The latter, called also the *cæcum*, consists of a swelling or enlargement, usually ovoid and smooth, but not unfrequently also covered by plaits and little muscular rib-like bands, more or less projecting. It is dilatable, and in some cases is swollen beyond measure, especially among certain aquatic tribes, such as the *Dytisci*. In these, as detected by the skilful eye of M. Dufour, the cæcum is no longer placed in the direction of the intestinal canal, but is thrown to one side, and furnished with a vermicular appendix, spirally twisted. It becomes inflated with air at the will of the insect, and thus seems to act the part of a swimming bladder. Other modifications of this organ have likewise been observed, into the detail of which we shall not here enter. The rectum is a muscular tube, in general of no great extent.

We shall next devote a few lines to the *biliary vessels*. That peculiar fluid called bile seems equally indispensable to the digestion of insects as to that of the higher animals, but the organ which secretes it is very different. In the former class it has no longer the appearance of a gland, but consists of more or less numerous vessels, of variable length, fixed for the most part by a single extremity, but not unfrequently by both ends, to the intestinal canal, and floating as it were in the abdominal cavity. These vessels are often rolled on themselves, and interlaced by numerous tracheæ and slender nervous filaments. They are never wanting in insects, and they exist equally in the larva state as in the perfect condition. They are delicate tubes, composed of a thin and pellucid membrane, on which certain transverse foldings produce a somewhat varicose appearance. They contain a liquid, sometimes limpid and colourless, but usually varying from yellow to brown. It is bitter, and exhibits all the characteristics of bile. The vessels themselves vary in amount from two, four, six, to an almost countless number. Their mode of insertion exhibits some remarkable variations, which however may be reduced to two great divisions: 1*st*, where the insertion takes place upon the ventricle alone; 2*d*, where it takes place upon the cæcum likewise. The first of these divisions offers two classes; sometimes the vessels are inserted only by one extremity, while the other is free or floating; sometimes they are fixed by both ends, and form so many arches. In the latter case they are few in number, and each arch may be regarded either as a vessel strongly curved towards the two points of insertion, or may be looked upon as composed of two vessels exactly anastomosed at their extremities. A coleopterous insect belonging to the genus *Donacia*, described by M. Dufour, was observed to possess a ventricle provided at once with arched vessels and with such as were free at their extremity. Such a combination connects, as it were, the characters which principally distinguish the first great division. The second great division above alluded to never presents us with any vessels that are free or unattached at one extremity. They form a complete arch from the ventricle to the cæcum, and scarcely present any particular character, except that their number is always restricted. The insertions on the ventricle are always more distinct than those on the cæcum; the latter being rarely isolated, but usually uniting into a smaller number of common branches, and sometimes into one.

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The *salivary vessels* consist of floating tubes, which open about the pharynx, and furnish a liquid to assist in deglutition. They are sometimes wanting or imperceptible, and are more general, as well as more highly developed, among the suctorial than the masticating tribes. The receptacles which supply the silk used by spinning caterpillars, are by many regarded as analogous to salivary glands, as are likewise the organs which furnish the venomous fluid in the mouths of Scolopendræ.[1]

CHAPTER IV.

THE METAMORPHOSES OF INSECTS.

As frequent reference is made, in the course of this treatise, to the metamorphoses of insects, we shall here endeavour to explain in what these essentially consist. "Were a naturalist," observe Messrs Kirby and Spence, "to announce to the world the discovery of an animal, which for the first five years of its life existed in the form of a serpent; which then penetrating into the earth, and weaving a shroud of pure silk of the finest texture, contracted itself within this covering into a body without external mouth or limbs, and resembling more than any thing else an Egyptian mummy; and which, lastly, after remaining in this state without food and without motion for three years longer, should at the end of that period burst its silken casements, struggle through its earthy covering, and start into day a winged bird,—what think you would be the sensation excited by this strange piece of intelligence?" Yet the difference which exists between the sometimes repulsive aspect of a creeping caterpillar, and the consummate beauty of the gorgeous butterfly to which it gives existence, is as remarkable as any supposable change from one form of animal life to another.

Although the ancients appear to have been aware that many insects, such as butterflies, bees, and beetles, proceeded from eggs, and underwent those changes which we name metamorphosis; yet, very shortly before the time of Redi, Swammerdam, Malpighi, and Leeuwenhoeck, to whom we owe so much of our present knowledge, Mouffet, who has been called the father of entomology, mistook the aquatic larvæ of Libellulæ for creatures entirely distinct from the perfect insects, and named them *Water Locusts!* The error was excusable, and has no doubt often been repeated in corresponding cases; for how many are ignorant, even at the present day, that the slender red-coloured wriggling worm, which is so often seen in collections of rain water,

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[1] Whoever inclines to enter fully into these subjects, will find in Messrs Kirby and Spence's *Introduction to Entomology*, not only a very ample and able account of the structure and functions of the various organs of insects, but also such references to the best informed writers, as will unfold a wide field for further study and reflection. See also *Entomologia Edinensis* (Introduction); the article *Insectes* in the *Dict. Classique d'Histoire Naturelle*, t. viii.; and M. Dufour's papers on Insect Anatomy, in the *Annales des Sciences Nat.*

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is the larva state of a clear-winged and elegantly formed fly, furnished with feathered antennæ and long slender limbs, the *Chironomus plumosus*? How entirely dissimilar is the hairy caterpillar, which we frequently observe crossing our foot-path in country lanes, from the richly attired tiger-moth which it eventually becomes? Many examples of a similar nature will probably occur even to the least instructed reader.

The word metamorphosis seems to have passed originally from a mythological meaning to a term in natural science. We had deemed it an ancient phrase, till we were informed by Mr Kirby that μεταμορφοω, and its derivative μεταμορφωσις, are not extant in any Greek writer before the date of the New Testament. They are used to express any *external* change of form or colour, and metaphorically any *inward* change and progressive improvement of the mind. The word metamorphosis, as applied to insects, is in fact synonymous with the more familiar term *transformation*, although, speaking strictly in relation to physiology, the changes indicated by these expressions should rather be regarded as a series of developments.

All insects proceed from eggs either previously deposited by the female parent, or, as in the case of the so-called viviporous (strictly ovo-viviporous) kinds, hatched within the body of the mother. Their first active condition is that of larva, which, according to the views of Swammerdam, contains within itself the germ of the future perfect insect, and those various envelopes, each of which, successively developed, becomes external and apparent by the casting off of that by which it was preceded.

Thus a caterpillar may be viewed, not as a simple, but a compound creature, containing within it the germ of the future butterfly, inclosed in what will become the case of the pupa, which is itself included in several more envelopes or skins, each of which becomes external in its turn. As the larva (so called from the very circumstance of its containing the *imago*, or perfect insect, shut up as it were in a *mask*) increases in dimensions, the various parts expand, and are thrown off, until at length the completed and more beautiful form is displayed in all its lustre. Swammerdam, in fact, discovered, by careful dissection, not only the skins of the larva and pupa incased within each other, but within these again the very butterfly itself, with its organs all complete, though nearly in a fluid state.[1]

Of the same fact, Mr Kirby states, any one may convince himself, without the skill of the great Dutch observer, merely by plunging into vinegar or spirit of wine a caterpillar about to assume the pupa state, and allowing it to remain there for a few days till it gains consistency of parts; or by boiling it for a few minutes in water. A very rough dissection will then enable the student to detect the future butterfly,—the wings being rolled up into a sort of cord, and lodged between the first and second segments, the antennæ and trunk coiled up in front of the head, and the legs, though very dissimilar in form, actually sheathed in those of the caterpillar. Malpighi, moreover, discovered the eggs of the future moth in the chrysalis of a silk-worm only a few days old;[2] and Réaumur those of *Bombyx dispar*, even in the caterpillar, seven or eight days prior to its change into the pupa state.[3]

According, however, to the more recent doctrines promulgated by Dr Herold, the successive skins of the caterpillar, the case of the pupa, and the members of the perfect insect (except the sexual distinctions, which he perceived even in the newly excluded larvæ), do not pre-exist as germs, but are formed successively from the *rete mucosum*, which itself is formed anew upon every change of skin, from what he denominates the blood, or the chyle after it has passed through the pores of the intestinal canal into the general cavity of the body, where being oxygenated by the air-vessels, it performs the nutritive functions of blood.[4] These proceedings, as usual, are attributed to a *vis formatrix*, a term of most convenient application where the mysterious workings of nature are but dimly seen or vaguely understood. But whatever may be the mode or principle of development, we know that insects exist in the four following states,—the *egg*, the *larva*, the *pupa*, and the *imago* or perfect condition.

The first stage of *life*, properly so called, is that of larva, in which existence is usually more prolonged than in any other, and in which the insect does nothing but eat voraciously, and increase rapidly, with intervals of repose occasioned by repletion. In this state it is entirely sterile. In the course, and towards the termination, of the larva state, that peculiar internal secretion the caul, epiploon, or fatty matter, formerly mentioned, is observed to increase, and the insect then assumes the pupa state, which is usually one of inaction and apparent torpidity. Ere long the skin of the pupa bursts asunder, or the wings and members become sufficiently developed for active exercise, and the insect assumes the perfect state, as exemplified in bees, beetles, and butterflies, all of which proceed from a worm-like larva. In this condition they are usually less voracious, their principal object and occupation being the preservation or continuance of their kind.

All insects, however, do not pass through these transformations. Most of the apterous kinds issue from the egg in a form very similar to that which they maintain throughout their after lives; from which circumstance Linnæus and others have bestowed the name of *complete pupæ* on their intermediate state, when such is recognisable. Even those that are subjected to the signal changes above described, differ considerably in the nature and degree of metamorphosis to which they are subjected. Many of the winged kinds experience no other change than the accession of the organs of flight. Their larvæ resemble the perfect insect, with the exception of the want of wings. Their pupæ, known as *semi-complete*, merely differ from the larvæ by exhibiting the rudiments of those organs the eventual development of which produces the completion of the perfect insect. Such are the grasshopper and locust tribes, in which the pupæ continue to exercise their locomotive powers and ordinary vital functions. Those insects which undergo a more entire metamorphosis are changed from larvæ into motionless and inert pupæ, and this mode of transformation presents different gradations. The pupæ, or nymphs as they are often called, of the Coleoptera and several other orders, exhibit their external members in close approximation to the body, but *free* or uncovered by any general envelope; we name them *incomplete*. But among the Lepidoptera, such as butterflies and moths, an elastic but firm and sufficiently solid skin or integument is moulded over the entire body and its various members, and only shows the form and outline of the latter visibly impressed upon its surface. These were called *pupæ obtectæ* by Linnæus. Dipterous flies, again, are covered in the pupa state by small simple cases, or egg-like shells, usually regarded as the skin of the larva, through which the form and proportions of the parts are in no way discernible. These were termed *pupæ coarctatæ* by the great Swedish naturalist.

When, however, we make use of the term *metamor-*

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[1] Hill's *Swammerdam*, ii. 24.

[2] *De Bombyce*, 29.

[3] *Memoires*, i. 359.

[4] *Entwicklungsgeschichte der Schmetterlinge.*

phosis, in relation to the different states of insects, another meaning is apt to result from the application of the words complete, semi-complete, and other adjective phrases,—for the less complete the pupa, the more complete the metamorphosis. Some confusion, we think, has arisen from this circumstance,—at least we have ourselves been occasionally puzzled by the contrariety of opinion expressed upon the subject even by the "master spirits" of entomology. Thus, Latreille observes, "Les Coléoptères subissent une métamorphose complète,"[1] while Mr Kirby has it "Metamorphosis *incomplete*,"[2] and the same form of expression is used by Mr Macleay.[3]

However this may be, our entire range of natural knowledge presents us with nothing comparable in singularity or beauty with the phenomena of metamorphosis. No wonder that the mystical sages of Egypt, and the refined philosophers of Greece, were so entranced or delighted with what they saw and fancied, as to found upon these changes many of the fondest fables which now pervade our classical literature. "Psyche," says Dr Nares, "means in Greek the human soul; and it means also a butterfly, of which apparently strange double sense the undoubted reason is, that a butterfly was a very ancient symbol of the soul. From the prevalence of this symbol, and the consequent coincidence of the names, it happened that the Greek sculptors frequently represented Psyche as subject to Cupid in the shape of a butterfly; and that even when she appears in their works under the human form, we find her decorated with the light and filmy wings of that gay insect."[4] Swammerdam himself, although his observations tended to prove that the analogy between the metamorphosis of a butterfly and the resurrection of the body, or second life of the human soul, was not so close as had been imagined, is yet of opinion that the process is so remarkable as to paint and exemplify that resurrection before our eyes.[5] "To see, indeed, a caterpillar crawling upon the earth, sustained by the most ordinary kinds of food, which, when it has existed a few weeks or months under this humble form, its appointed work being finished, passes into an intermediate state of seeming death, when it is wound up in a kind of shroud and incased in a coffin, and is most commonly buried under the earth (though sometimes its sepulchre is in the water, and at others in various substances in the air); and, after this creature and others of its tribe have remained their destined time in this deathlike state, to behold earth, air, and water, give up their several prisoners; to survey them, when, called by the warmth of the solar beam, they burst from their sepulchres, cast off their cerements, from this state of torpid inactivity come forth as a bride out of her chamber,—to survey them, I say, arrayed in their nuptial glory, prepared to enjoy a new and more exalted condition of life, in which all their powers are developed, and they are arrived at the perfection of their nature; when, no longer confined to the earth, they can traverse the fields of air, their food is the nectar of flowers, and love begins his blissful reign;—who that witnesses this interesting scene can help seeing in it a lively representation of man in his threefold state of existence, and more especially of that happy day, when, at the call of the great sun of righteousness, all that are in their graves shall come forth, the sea shall give up her dead, and death being swallowed up of life, the nations of the blessed shall live and love to the ages of eternity?

"But although the analogy between the different states of insects and those of the body of man is only general, yet it is much more complete with respect to his soul. He first appears in this frail body—a child of earth, a crawling worm, his soul being in a course of training and preparation for a more perfect and glorious existence. When it has finished this course it casts off this vile body, and goes into a hidden state of being in Hades, where it rests from its works, and is prepared for its final consummation. The time for this being arrived, it comes forth clothed with a glorious body, not like its former though germinating from it, for though 'it was sown an animal body, it shall be raised a spiritual body,' endowed with augmented powers, faculties, and privileges, commensurate to its new and happy state. And here the parallel holds perfectly between the insect and the man. The butterfly, the representative of the soul, is prepared in the *larva* for its future state of glory; and if it be not destroyed by the ichneumons and other enemies to which it is exposed, symbolical of the vices that destroy the spiritual life of the soul, it will come to its state of repose in the *pupa*, which is its Hades; and at length, when it assumes the *imago*, break forth with new powers and beauty to its final glory and the reign of love."[6]

Swammerdam, to whom we owe the earliest philosophical examination of the subject, divides the phenomena of metamorphosis into four classes. In the first, in which the changes are the least varied or remarkable, he includes apterous insects commonly so called, most of which we now name Myriapoda, and the metamorphosis of which consists in gaining additional segments and pairs of feet; also Arachnides and Crustacea, which are for the most part characterized by simple renewals of their envelope. In the second class he places such insects as are born with six feet, but have their wings concealed or inclosed in a sheath during a rudimentary period, such as Orthoptera, Hemiptera, and many Neuroptera. In the third class are included those insects which exhibit three distinct conditions; they compose two subdivisions. The first comprises those insects of which the second state, called nymph or semi-nymph, exhibits either the appearance of feet and wings, or the reality of these organs. They are not reduced to that state of utter lethargy or apparent death which some present, and they include the remainder of the Neuroptera, the Hymenoptera, and the Coleoptera. The other subdivision contains the Lepidoptera, of which the larvæ, commonly called caterpillars, are subject to several preparatory changes of their coat, and are finally converted into chrysalids, through the coriaceous skin of which the interior parts are perceptible, but which externally exhibit neither wings nor legs, nor any other members.

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[1] *Règne Animal*, t. iv. p. 354.

[2] *Introduction to Entomology*, vol. iv. p. 369.

[3] *Horæ Ent.* p. 440. The confusion above referred to may perhaps have arisen from certain adjective phrases having been at times applied indifferently, either to the state of pupa or the phenomena of transformation, which in most cases causes a contradiction in terms. In Orthoptera, of which the pupa is semi-complete, the metamorphosis may bear the same designation; but in the other orders the double application of any of the adjective terms leads to inaccurate ideas. Thus, in Coleoptera, the pupæ are *semi-complete*; but there is surely a total transformation, that is, a *complete* metamorphosis, when we compare together the larva and the perfect insect. So also in Lepidoptera, the pupa is obtected; in Diptera, coarctate; and consequently the metamorphosis must be *complete* in both. Now Mr Kirby makes use of the phrase "metamorphosis obtected" in regard to the former, and "metamorphosis coarctate" in relation to the latter,—terms which we have been in the practice of applying to the pupa state of these orders, but not to the general transformations. The same admirable author, in defining apterous insects, states the metamorphosis to be *complete*. We would rather say that they undergo *no* metamorphosis at all,—for which very reason, each particular state, or rather period, of the insect, is itself complete from youth to age. The less complete the pupa, the more complete the metamorphosis, and *vice versa*.

[4] *Essays*, i. 101.

[5] Hill's Translation of the *Biblia Naturæ*, i. 187.

[6] *Introduc. to Ent.* vol. i. p. 75.

Finally, in the fourth class are included all those insects which on their exclusion from the egg exist as vermiform apodal larvæ, are provided at most with six feet, and are converted into nymphs without a change of envelope, so that their skin merely hardens over the intermediate state of the insect, which ere long issues winged. Such are the dipterous tribes.

These views and combinations have been somewhat modified in later years, by Réaumur, Linnæus, Fabricius, Huber, Dutrochet, Savigny, Marcel de Serres, Latreille, and others who have devoted themselves to the investigation of metamorphoses. Those phenomena have consequently been classed as incomplete or partial by which the aspect of the insect is merely modified, and as complete or total by which it is entirely changed. In all, the interior changes may be said to command the exterior, that is, the latter are consequent on the former. In numerous species, not less than three of the principal organic systems, viz. the *nervous*, the *nutritive*, and the *respiratory*, undergo important modifications, and we may easily conceive how strongly the instinctive habits of the individual must be thereby affected. The alterations in the nervous system especially, are singular in their nature and effects. The number of ganglia of the spinal cord is usually greater in the larva than the perfect insect, although the great single ganglion of the rhinoceros-beetle (*Oryctes nasicornis*), in its early state, compared with the four ganglia of its subsequent condition, offers an exception to the general rule. But in the larva of the stag-beetle (*Lucanus cervus*) we observe eight ganglia, besides a recurrent nerve, while the perfect insect possesses only four; and among caterpillars in general the same restriction takes place in the number of their ganglionic knots as they attain the perfect state.

Among beings in which the parts representing the brain and other organs of sensation of the higher tribes undergo so many variations even in the same individual, we may well suppose that whatever ideas they are capable of conceiving at one period of their existence, may differ essentially from those with which they are impressed at another. We shall not here involve ourselves in the discussion of the difficult and dissimilar theories of instinct, nor enter into any exposition of the mechanical, the intellectual, or the supernatural character of that surprising manifestation, which, under whatever aspect it may be viewed, whether as differing in kind or only in degree from reason, cannot be otherwise regarded than as a most beautiful illustration of divine benevolence. But we may ask, by what peculiar memory or mode of recollection does the brilliant butterfly, which seeks its sustenance in the nectarous juices of flowers, rifling their sweets with its tubular *proboscis*,—by what means does it remember that its progeny, while in the larva state, must be sustained by a far different diet, and that they exercise their *jaws* on cabbage-leaves, and other vegetation of the coarser kind? M. Virey, who denies all intellect to insects, and views their various actions as resulting mechanically from the peculiar disposition or character of their nervous system, has endeavoured to illustrate the subject by the following parallel. He compares an insect to one of those portable organs, of which the cylinder has different airs noted on its surface, and which performs one or another tune in proportion as the cylinder is made to recede or advance. So likewise the nervous system, or series of ganglia along the double medullary cord, of the creatures now under consideration, being differently constituted in the larva and the perfect insect, ought to produce different actions in the two cases, though respectively appropriate to the nature of each. Art in the one instance, and nature in the other, has impressed certain dispositions, or notes of action, fixed in a determinate series, equally in the musical organ, and the ganglionic system of caterpillars. Hence the one gives utterance to a certain air, while the other acts according to a certain sequence of operations. Pull out a notch of the barrel organ, and you have another tune; await the transformation of the caterpillar to a butterfly, and you have (with a change in the *notching* of its nervous system) another series of instinctive operations. In both, the relations of cause and effect are the same, and each is merely the mechanical playing of an instrument![1] Now, to prove this position, as has been elsewhere remarked, M. Virey ought at least to have shown, that whenever a change takes place in the instincts of insects in their different states of larva and imago, a corresponding change also takes place in the structure of the nervous cord.[2] But this is by no means the case. In three entire orders, namely, Orthoptera, Hemiptera, and Neuroptera, the structure of that cord remains unchanged, and yet we know that thousands of the species which compose these orders acquire instinctive habits in their perfect state, altogether dissimilar to those by which they were characterized in their earlier condition. Even were it otherwise, our query would still require to be answered, by what mechanical impulsion is the completed butterfly, a gay and gorgeous honey-sucker, induced to play a tune (we speak in harmony with M. Virey's views) so completely in accordance, not with its own refined tastes, but with the future welfare of the crawling caterpillars of which it is the parent? Why does it deposit its eggs, not on the odorous blossoms and bright consummate flowers in which it takes so much delight, and amid the varied petals of which it rejoices to expand to the sunshine its own still more brilliant wings, but on the rank leaves of the cabbage and cauliflower, or the dingy foliage of the nettle? These questions, and many others of a similar nature, are perhaps more easily proponed than answered. When we consider, indeed, how frequently inaccurate is our knowledge even of our own individual feelings, and how much more incompetent we are to judge of what passes in the minds of others of our own species, need we wonder that the sentient principles of the lower animals should, in relation to human intelligence, be still shrouded in dim eclipse, if not in total darkness.. It is far more probable, however, that the alterations in the nervous cord have no necessary connection with the changes of instinct, but are more closely concerned with those other not less remarkable mutations in the organs of sense and motion, which occur between the larva and imago states of several orders. "In a common caterpillar, the form of the body, the legs, the eyes, and other organs of the senses, all strikingly differ from those of the imago; whereas, with the exception of the acquisition of new wings, a perfect locust differs little from its larva; so that we may reasonably expect a corresponding change, such as we find it in the structure of the nervous cord of the lepidopterous insect, not called for in that of the neuropterous (orthopterous?) species, in which accordingly it does not take place."[3]

Metamorphosis frequently induces no less remarkable changes in the *system of nutrition* of insects, followed of course by corresponding alterations in their instinctive appetites and modes of life. In such as undergo an incomplete metamorphosis, the parts of the mouth, and the form of the alimentary canal, experience no essential alteration; but among those tribes in which the change of external aspect is complete in each successive stage, these import-

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[1] *Nouv. Dict. d'Hist. Nat.* xvi. 313.

[2] *Introd. to Ent.* iv. 27.

[3] *Ibid.* vol. iv. p. 28.

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ant parts assume another character, and admirably illustrate the multitude of means employed by nature to vary her innumerable products, even although the general laws by which these are regulated, and from which, under the great and never-slumbering eye of Omnipotence, they more immediately result, are themselves so few in number. The shorter the alimentary canal becomes, the more carnivorous are the tendencies of the individual. This finally exemplifies the great physiological truth previously deduced from the difference between the structure of the alimentary system in herbivorous and carnivorous animals of the higher classes,—between the short canal of the blood-thirsty tiger, and the lengthened convolutions of the gentler ruminating tribes. Here, however, the disparity exists, not as among animals of entirely different attributes, but in the same individual at different periods of its existence. The young of many aquatic beetles of the family of *Helophoridæ* are carnivorous in their larva state, and become herbivorous on assuming their final transformation. A like singularity is manifested by many dipterous flies, which, born and bred amid the putrid moisture of animal remains, no sooner become winged insects, than they seek a purer diet in the nectarous juices of fruits and flowers.[1] Analogous changes take place even in those species which do not entirely alter the nature of their diet. A voracious caterpillar, which, by means of its robust maxillæ, rapidly gnaws and consumes a quantity of the most coriaceous leaves, to the amount sometimes of triple its own weight in a single day, and presents the beau-ideal of an eating machine, has its intestine greatly dilated, and pursed like a colon. The larvæ both of wasps and bees have a stomach so vast, that it occupies almost the entire of their interior, although in the perfect state of each it becomes greatly restricted. Thus in the bee that great laboratory consists of little more than two unequal honey pouches; and among butterflies, of which the trunk or sucker corresponds to the previous jaws, the stomach is much less than in caterpillars. This, we may observe, reverses the rule which applies to the great ruminating animals among the vertebrated tribes, where we find a single stomach in the fœtus state, and which in the adult is multiplied to four. It is the opinion of some naturalists that larvæ in general, having larger intestines, tend more towards a herbivorous diet than perfect insects, in which these organs are shorter, and which are consequently supposed to assume a more carnivorous habit;—"so rare is it," observes M. Bory St Vincent, "to perceive the manners of living creatures not tending to mutual destruction as their powers are developed." An enlightened mind, however, naturally delights in the perception and extrication of general rules; and these, we fear, are not seldom fancied without being either perceived or deduced. In opposition to the presumed law, we have already mentioned the *Helophoridæ*, which reverse the rule; and to these we could add many more. The glow-worm in its larva state is greedy of animal juices, and feeds chiefly on minute testacea, while, in its completed state, it is entirely herbivorous. A large aquatic beetle, the *Hydrous piceus*, is so ferocious and blood-thirsty in the form of larva, as to bear in France the name of *ver-assassin;* but in its after condition, through the medium of metamorphosis, the intestine becomes elongated, and the disposition of the insect is softened and subdued, so that it then prefers a vegetable to an animal diet. In fact the great aim and object of an insect in the perfect condition is rather the continuance of its kind than the sustenance of itself; although, as the one process cannot be well accomplished without the other, it no doubt, even in its most high and palmy state, casts, like its betters, an occasional eye on the "flesh-pots of Egypt."

The changes in the *respiratory system* of insects produced by metamorphosis, are not less extraordinary than those to which we have just alluded. But as we have already mentioned some of the more remarkable of these in our observations on the *organs of respiration*, we shall not further dilate upon that portion of the subject.

Metamorphosis in insects has been described as the maximum state of a general law of nature, by which the whole organization of the animal being is gradually developed and made fit for reproduction. Without the study of this phenomenon, we cannot acquire a knowledge of the most important circumstances in the lives of such animals as are guided entirely by instinct; and just as an acquaintance with the whole life of an insect necessarily induces a truer knowledge of its actual nature, than a mere description of one of its forms,—so, in the same proportion, it has been said, ought metamorphosis to outweigh every other principle of arrangement. When we trace the natural history of a dragon-fly (*Libellula*) from the time that the egg is first dropped into the bosom of the uncertain waters, till, on some bright sunny morning in "the leafy month of June," the gauzy-winged insect in the perfect state is seen to rise from its moist abode, and, hawking for flies, to hover like a bird of prey along the placid shores of some familiar pool, we can scarcely conceive a clear idea of the truth, except by supposing one animal to have been so inclosed within another, that the imago is in a great measure distinct from the repulsive larva, and is only opened to our view by its desiccation or death. Hence, as Mr Macleay observes, a system unconnected with metamorphosis may be regarded as taking no more notice of half the number of true insects than if they did not exist. "It is the defect both of the artificial system in Entomology, and of the sexual system in Botany, that they become useless, except when the objects of the respective sciences are before us in one particular state, which is often the most transitory of their life. Unless this condition be fulfilled, such systems lose their sole and peculiar merit of being dictionaries by which natural objects may be named. There are thousands of organized beings, to the history and knowledge of which the disciple of Linnæus and Fabricius has no clue whatever, although perhaps they are in that state of their existence which most directly affects the interests of man. Plants not in flower, and insects not in their declared state, constitute an ocean of difficulties, in which the most skilled in the Linnæan nomenclature will founder, unless he have other beacons than such momentary considerations as are afforded by the number of stamina, or the form of the antennæ."[2]

We shall conclude our observations on the singular subject of metamorphosis, by another quotation from the last-named author, which, with what has been already stated, will, it is hoped, suffice to instruct the reader regarding what we consider the most extraordinary phenomena observable within the range of the animal kingdom. "It was perfectly in unison with the innate propensity of the human mind towards the marvellous, that the change of a caterpillar into a butterfly, when first noticed, should have been considered by the ancients as a true transformation, irreconcilable with the ordinary course of nature. Even on the mystery being in a great degree cleared up by the discoveries of Libavius, Redi, Malpighi, and Swammerdam, the phenomenon continued to be termed metamorphosis; and perhaps it is even still a little owing to such circumstances that a natural process, neglected in other branches of zoology, has always excited so much curiosity among entomologists. Metamorphosis, however, has been taken of late in a very general point of view, and rendered synonymous with that species of organic decomposition which, by means of continual shedding of the external envelopes, or even of the various integuments which may compose those envelopes, occasions that extraordinary characteristic of a living body, namely, that it never remains in a constant state, or identically the same, but is continually assimilating new particles of matter, as it throws off the old. And since no metamorphosis can take place except in consequence of these integuments being shed, perhaps it may not be altogether improper to survey the subject in this light. What I mean is, that we ought to regard the metamorphosis or change of form which certain animals undergo at various periods of their life, as an attendant upon, if not a variety of, the *ecdysis*, or moulting, to which all organized beings are subject. There is, however, a great distinction to be made between the *ecdysis* of the *Vertebrata* and *Annulosa*, for in the former we observe little more than that the animal has quitted a sheath in which it was inclosed; whereas in the latter the change is nothing else than if the skeleton were shed; for this name is surely deserved by those hard and solid parts which in so many cases afford support to the muscles. It is clear that such a process must occasion a crisis in the life of an annulose animal, incomparably more decisive in its effects than what can be produced among the *Vertebrata*, by merely being set free from an integument. All the marvellous, however, of *ecdysis*, was with the earlier naturalists comprehended in the change of form; and consequently the shedding of the envelope only excited attention where it regarded a few of the *Annulosa*. Hence it was a great discovery of Linnæus, that every annulose animal ought to be considered as subject to metamorphosis. It may indeed have led to his more artificial notion of every externally articulated being having a nympha state; but even this helped Fabricius to give, although with a faulty nomenclature, a much more convenient division of metamorphosis than he could otherwise have devised.

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[1] *Entomologia Edinensis*, p. 207.

[2] *Hor. Ent.* p. 449.

"Ecdysis, by which term is signified generally every change in the identity of the envelope of a living body, may either be complete or incomplete. If it be incomplete, or, which is the same, if the integuments scale off piece by piece, we have that mode of change which is peculiar to the most perfect of the *Vertebrata*, and to the least perfect of the *Annulosa*.

"Complete ecdysis is the shedding of the whole external envelope at once, of which we have examples among the vertebrated as well as annulose animals. It is of three sorts; first, where the external envelope is shed without producing any essential change of form, except in as much as may relate to the increased size. In those larvæ of insects which become inactive in their pupa state, such a process may always be distinguished from the true metamorphosis; but in apterous Hexapods having active nymphæ, they are necessarily confounded. It is also visible in reptiles and spiders, where such appendages of the trunk as have been lost may be reproduced by continued moulting. When the various envelopes are all cast as it were in one mould, it is to be expected that the proper form of the animal should re-appear as these continue to be thrown off. The return therefore of a spider or crab, after having lost a limb, to its original form, may be in some measure understood as depending on the manner in which such animals shed their envelope; but that the limbs thus shot forth should be furnished with muscles and nerves, is, I conceive, what cannot be accounted for, except by referring to that polype nature of the cellular substance, which is perhaps, in the opinion of some persons, the foundation of all ecdysis. If perfect hexapod insects cannot reproduce their members, this inability may probably proceed from a cause which appears to have produced the same effect among *Mammalia* and birds, to wit, that these animals in their perfect and final form are all subject, if to any, at least to a very imperfect ecdysis.

"The second sort of complete ecdysis is that where the under envelope has been cast in a somewhat different mould from the upper, so that in the course of the moulting certain new parts become gradually developed without the general form being in any material degree altered. This is observable in every annulose class, as well as in Humboldt's Axotl among the *Vertebrata*, and is the first species of change which merits the name of metamorphosis. It includes the *Metamorphosis inchoata* and *Metamorphosis dimidiata* of Latreille, and is the same with the *Metamorphose partielle* of Lamarck.

"The third sort of complete ecdysis is that wherein, by some two or three moultings, generally the last which the animal has to undergo, the form is entirely changed, as well as the number of appendages more or less increased. This is clearly a true metamorphosis, and includes the other two sorts of complete ecdysis; for we have here combined a total casting of the integuments, a development of additional appendages, such as feet or wings, and finally an entire change of form. Such a combination may be witnessed, among the *Vertebrata*, in frogs, and, among the *Annulosa*, in certain hexapod insects. Hence, in confining ourselves to plain and open ecdysis, there will be no great error in stating that the most imperfect takes place in the highest *Vertebrata* and the lowest *Annulosa;* while the most complete ecdysis is that which is seen to prevail in the highest *Annulosa* and some of the lowest *Vertebrata.*

"In strict accuracy, however, it appears that we ought to acknowledge the existence of complete ecdysis throughout the circle of *Vertebrata.* Nay, some physiologists have attributed insect metamorphosis itself to a shedding of an envelope analogous to that which contains the fœtus of the more perfect *Vertebrata.* As every embryo, whether animal or vegetable, is enclosed in a tunic more or less solid, which is its chorion, so, proceeding with the analogy, they conceive that there must be some condition for every animal, similar to the state of the fœtus of the more perfect animals when surrounded by the amnios; and this state in batrachian reptiles and hexapod insects they hold to be the larva. The only danger of this reasoning is, that while we find the birth of an animal to be attended with complete ecdysis, we may be apt to imagine that every complete ecdysis betokens a true birth. It would, however, be truly absurd to consider the casting of their shell by *Crustacea*, or the periodical moulting of the serpent, in this light; yet no one can doubt the fact of both these being cases of complete ecdysis, only differing from that of *Lepidoptera*, because in the former animals the external envelope is always of the same form as that of which it is to take the place. The truth perhaps is, that we ought only to allow two states to every animal, a perfect and an imperfect state. Then, by the reflection that no animal out of the circle of *Aerita* can ever arrive at its perfect state except by means of metamorphosis, and that when perfect it can never again be subject to this change of form, though it may still moult or shed its external envelope, we may be able, if not to comprehend the cause, at least to know the effect, of some of the most puzzling phenomena in nature. The true criterion of animal as well as vegetable perfection is the ability to continue the species; hence some of the *Vertebrata*, as well as *Annulosa*, gaining this faculty before they have arrived at their proper type of form, metamorphosis ceases, and they preserve the shape of larvæ.

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"But if a complete ecdysis may sometimes create a total change in the external appearance of the animal, the fact, however astonishing, is nothing in comparison of the internal metamorphosis which accompanies it, and of which as yet no philosopher has been able to give any satisfactory explanation. The generalization indeed by which we have reduced the moulting of a bird's feathers and the metamorphosis of a butterfly to one principle, may appear to be strained beyond its proper limits; yet if we contemplate the regular gradation from one to the other, how truly, for instance, the inactive pupa of a beetle corresponds with the agile nympha of a *Gryllus*, how this ecdysis in an apterous *Gryllus* corresponds with the sloughing of a spider, and this again with the annual renovation of the serpent, we must be sensible that, however dissimilar the extremes may be, all these changes are modifications of one principle. But what particularly deserves remark is, that these extremes should often be visible in neighbouring groups; nay, in the same order; that, in short, metamorphosis should differ so much in degree even where the animals are near in affinity. An orthopterous insect may preserve the same form and habits from the instant it quits the egg up to the period of its death, the only qualities obtained by ecdysis being an augmentation of size and an aptitude to continue the species. But if we turn to the order of *Coleoptera*, which is contiguous in affinity, it is truly wonderful that, by metamorphosis, not only the form, but the nervous and digestive systems, may be altered, and the organs connected with these primary functions may all be of a construction different from that which they originally possessed."[1]

The reader has now been made acquainted in a general way (and as precisely as the limits of our present article may admit) with the most characteristic features in the structure of the insect tribes, from which he may form some opinion of their real nature. Their relative position in the magnificent range of created things is a subject deserving of a deeper and more extended examination than we can here bestow upon it; but as we are unwilling to leave such an interesting matter of philosophical consideration entirely unregarded, we shall here enter into it in the only way compatible with our prescribed limits.

CHAPTER V.

OF THE RELATIVE POSITION OF THE CLASS OF INSECTS IN THE ANIMAL KINGDOM.

A great diversity of opinion has existed from the earliest ages regarding the natural affinities of the different kinds and classes of animated beings to each other, and a consequent contrariety has prevailed in our systems of classification, which are of course indications of the relation of groups, unless where, for mere convenience, a professedly artificial basis of arrangement, deduced from one or two obvious though unimportant characters, may have been adopted. The majority of naturalists, both ancient and modern, have proceeded upon the idea that all natural objects were *concatenated*, or formed a continuous *chain* or linear series, and that whatever hiatus might seem to exist arose either from some great convulsion which had swallowed or swept away the desired links, or from these links being still to be discovered in one or other of those regions of the earth's surface which still remain to be explored. Hence the dictum of Linnæus—natura saltus non facit. "When the ALMIGHTY CREATOR," says Mr Kirby, "willed to bring into existence this mundane system, he formed it according to a preconcerted plan, with all its parts beautifully linked together and mutually corresponding. All things were ordered in *measure*, and *number*, and *weight*.[2] There was nothing deficient, nothing superfluous; but the whole, in the strictest sense, 'was very good,'[3] and calculated in the highest degree to answer the purpose of its GREAT AUTHOR."[4] Observation and analogy alike combine to prove that there is a regular approximation to each other in the works of God, and that they are related to each other in a variety of ways both naturally and analogically; but it need not be supposed that, in the magnificent plan of the creation, there is no disparity in the relative position of the most nearly related kinds, and no greater interval in one place than another. There is in truth a great variation in the combinations of living beings, though no violent break or sudden interval; in other words, "some continuous species or groups have more characters in common than others." But in considering the various groups of living creatures, we must ever bear in mind our own ignorance of their actual amount, and the thousands of unknown forms which in all the pride of life may be daily unfolding their exquisite forms and gorgeous colours amid those far deserts where man has never trod, and which for that very reason he regards as *solitudes*, though assuredly teeming with all the inexplicable wonders of creation. Let not therefore a *hiatus* be confounded with a *saltus*, the former being merely one of the many blanks in the superficial map of knowledge drawn by man, the latter an absent link in that resplendent chain, to us too often "dark with excessive light," which in one way or other connects together in divinest harmony the beautiful works of the Creator. That the series of beings, however, was not only continuous, but *undeviating*, and ascended in a direct line from the lowest to the highest, was maintained, among many others, by the excellent and ingenious Bonnet, and has generally prevailed till very recent times.

Now the principle which mainly characterizes the views so mildly advocated by Mr Macleay, and entertained, we believe, about the same period, although without communication, by Agardh, Fries, and other continental naturalists, is this,—that although the natural arrangement of objects is indeed in a continuous series, that series in its progression forms various convolutions, each of which may be represented by a *circle* or series returning into itself. He maintains that absolute divisions do not exist in nature, and that a single plan pervades the universe, a plan founded on the principle of series of affinities returning into themselves, and forming circles; hence there is no such thing among natural objects as a simple progression of species.[5]

If it were true that the descending scale, as so long supposed, in the perfection of organization, was regular from man to the infusorial tribes, then the lowest of one form of life would naturally lead to the highest of the next ensuing, and the most simply organized of the vertebrated classes would connect most nearly with the most complex of the invertebrated kinds. But this, as we shall afterwards see, is not the case.

Although naturalists, if we may judge from their sys-

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[1] *Hor. Ent.* p. 441.

[2] *Wisdom*, xi. 20.

[3] *Genes.* i. 31.

[4] *Introduc. to Ent.* iv. 356.

[5] The latter sentiment appears to have been also entertained by Latreille in his later years. Writing of certain coleopterous insects, he observes, "Les Dryptes ont aussi des rapports avec les Cychrus, et paraissent lier les Cicindelètes avec la section des Carabiques grandipalpes. Plusieurs sections de cette famille semblent se rattacher, comme autant de rameaux, aux Cicindèles. La plupart des autres familles d'insectes sont dans le même cas, ou forment des troncs ramifiés. *En un mot, des séries continues n'existent pas dans la nature.* (Note to *Règne Animal*, t. iv. p. 373.)

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tems of classification, are accustomed to consider the insect tribes as inferior in the great range of organization to the molluscous animals which inhabit shells, there can be no doubt that they are superior in many of their vital functions. Their powers of locomotion, whether as winged, aquatic, or terrestrial creatures, are finely developed, and their perceptive faculties are much more acute. The symmetrical perfection of their forms, and the articulation of the limbs, in the insect class, seem also in some measure to connect them with the vertebrated tribes. Indeed, even of the latter, many seem far inferior to insects, not only, as Mr Macleay has observed, in the possession of those faculties by which we are accustomed to estimate the rank of the *Vertebrata* among themselves, but also in the complication of their general structure. These and other considerations afford powerful arguments in favour of the *circular* system; for it appears necessary, first, that certain affinities of the *Mollusca* to the *Vertebrata*, and which are obvious in the *Cephalopoda* or cuttle-fish, should not be disturbed by any intervening division; and, secondly, that the annulose animals themselves, such as insects, Crustacea, and Arachnides, should not be far separated from *Gastrobranchus* and other genera of cyclostomous fishes; above all, that they should not be made subordinate in rank to such simply organized creatures as compose the greatest part of the Mollusca. "Now these conditions will all be fulfilled if the chain of nature be viewed as returning into itself; whereas they will be completely violated if we account it to be a regular line or ladder, commencing with the *Infusoria*, and terminating in man; or indeed if we adopt any opinion that has hitherto been advanced on the subject by naturalists."[1] It seems to have been chiefly owing to the perfection of the circulating system in molluscous animals that they have obtained their present rank; for, in regard to the nervous system, which would have been a truer test, although such tribes as possess a distinct head, and are furnished with tentacula and other organs of sense, have undoubtedly a true brain, yet oysters and many more *acephalous* kinds can lay no other claim to the possession of that organ than what is derived from the analogy which its position in these Testacea is supposed to bear to that of the brain in the gasteropoda. It is a strong fact, however, that so skilful an interpreter of nature as Baron Cuvier should have been determined by that analogy, and should have acceded to the acephalous Mollusca the possession of a brain, and a general construction, which, upon the whole, he regards as making a nearer approach to that of the *Vertebrata* than is effected by any annulose animal. Yet in spite of this it would be difficult to contend that an *Ascidia* is in any respect superior to a bee, as no one who has ever seen the two, and observed their respective functions, would venture to bring the sluggish mollusc into competition, either as respects intelligence or complication of mechanism, with the delightful emblem of industry.

When we call in the aid of anatomy to determine the relative importance which different material beings bear in the scale of the creation, we must consider the beauty of the general mechanism and (speaking humanly) the difficulty of the workmanship, and not any "fancied and often forced resemblance to the human structure."[2] It is in truth a great error to regard the works of the creation as referable to the human structure, as a standard of perfection; for although the frame of man, when taken as a whole, ought doubtless to be regarded with wonder and admiration as a most complicated yet complete machine, there is at the same time as little doubt that we scarcely possess a single sense or bodily power in which we are not excelled by some irrational beings. Different animals have in fact been constructed on different plans, and man may without impropriety be regarded as upon the whole the most admirably constructed creature of all those which have been organized upon the same general plan with himself, but with the others he cannot be compared.

In the article ANIMAL KINGDOM of this work we have already shown the importance of the nervous system in the formation of the greater divisions of living creatures, and we there exhibited the relative positions occupied by the different classes of animals in the works of the most distinguished systematic writers. Lamarck divides the animal kingdom into two great branches,—the one containing all those living beings of which the skeleton is *internal*, and constructed upon a bony and articulated column, hence called *Vertebrata*,—the other consisting of those innumerous kinds of which the skeleton is either wanting, or its supposed analogue is for the most part *external*, and includes the muscles; these are the *Invertebrata*. This grand distinction is strongly marked throughout the great mass of each division, but it begins to disappear wherever the provinces approach each other. Thus among the turtles or chelonian reptiles, the vertebral column is converted to a row of square osseous plates, which run along the back, and unite with eight pair of expanded ribs, which are anchylosed together by real sutures, and combine to form in fact the *external* carapace or shell. In like manner the vertebral column almost disappears among the cyclostomous fishes, while, on the other hand, the Cephalopoda, or cuttle-fish, though belonging to the invertebrate division, exhibit the commencement of an internal skeleton. M. Virey, as we have shown in the article above referred to, divided the animal kingdom into *three* great branches, according to the different character of their nervous system. Baron Cuvier, proceeding upon the consideration of the same important basis, includes all animals within *four* primary divisions; while Mr Macleay, according to his peculiar views, perceiving *five* great sub-kingdoms in the magnificent *circle* of living things, has assumed that number of divisions. We shall here present a sketch of his system, so far as relates to the primary forms, the majority of which agree with those of his predecessors, although their relative position, and circular sequence, if we may so call it, differ.[3]

1*st*, There is a great tribe of beings which possess one principal centre to their nervous system, the great trunk of which, with the said centre, is contained in a bony articulated case, which forms the axis of the whole body, and constitutes the vertebræ and skull of these creatures, which are therefore named VERTEBRATA.

2*d*, In another form of animals the skeleton is as it were external, so as to envelope the whole body, and is divided by transverse folds into a certain number of rings, to the internal surface of which the muscles are always attached. Their nervous system consists of two long strings of medullary matter, passing through the whole of the body, and united to each other, at small distances, into several knots or ganglia. These ganglia may be said to perform for the parts which surround them the function of so many brains, and for a certain period are even sufficient for ner-

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[1] *Horæ Entomologicæ*, vol. i. p. 206.

[2] *Ibid.* p. 405.

[3] As the book entitled *Horæ Entomologicæ* has been long out of print (the author has never brought out a second edition, and the first was almost totally consumed by fire), our occasional exposition of its peculiar and prevailing doctrines cannot prove otherwise than interesting to the considerate reader.

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vous sensibility after the animal has been cut in pieces. All the beings so constructed are named Annulosa.

3*d*, In a third prevailing form there is no articulated skeleton either external or internal, the muscles being attached solely to the skin, which is itself in general soft, though often protected by a calcareous or stony crust, termed the shell. These animals, remarkable, like plants, for the variety of modes in which the sexes are combined, have their nervous system composed of several masses or ganglions united together by nervous threads. The constituents of this group are almost all aquatic, and are named Mollusca.

4*th*, A fourth form of animal life exhibits to our view the organs of locomotion and sensation arranged in a circular disposition round a centre, so as to give a sort of radiated aspect to the whole body. They are composed of a more or less gelatinous substance, of which the fibres are indistinct. The nervous system of these imperfect beings is but little known. M. Tiedemann, in a work crowned by the French Institute (*Mémoire sur l'Anatomie des Astéries*), conceives that the whitish threads which proceed in a radiant direction from around the mouth, and which extend themselves through the entire length of the arms of these animals, form a kind of nervous system, which, from the pulpy nature of the medullary matter, seems to correspond with the gelatinous composition of the animals themselves. They are all aquatic, and are named Radiata.

5*th*, Thus far these groups agree in number and constitution with the four primary divisions established by Baron Cuvier,—the *Annulose* division corresponding with the *Animalia Articulata* of the French naturalist, except that it excludes the *Annelides*, or red-blooded worms, and includes certain radiated species (commonly so called), such as the intestinal group denominated *Intestinaux Cavitaires* by the French, or *Entozoa Nematoidea* of Rudolphi. But, according to Mr Macleay's views, there still remains a *fifth* form of animal life to be considered,—a group of beings which cannot in the present state of knowledge be better described than as masses of a transparent, homogeneous, mobile, and sensible pulp. There may, however, be observed in this translucent mass innumerable minute granulations, which may be regarded as the nervous molecules dispersed over, or as it were confounded with, the substance of these animals, so as to endow the whole with sensibility, or something which the author calls such, probably for want of a better name. This final division is named Acrita.[1] Its constituents form a portion of the *Animalia Radiata*, or fourth primary division of the Cuvierian system, and include the infusory animals, many of the intestinal worms, and the *polypi*. Their distinctive character is principally negative in reference to animals, and positive in regard to plants. The simple texture of their cellular tissue is common to them and to the *Algæ*. Their gemmiparous generation is allied only to the very simplest mode of the reproductive system among other animal tribes, but is by no means unfrequent among plants. The method by which they are more or less sustained by the absorption of their external pores, and the attractive influence exercised on them by light, are likewise features only elsewhere to be observed among the vegetable tribes. When a polype is cut in pieces, each of these continues to live, and in time assumes the original form, so that every point of such an animal body may be regarded as possessing an independent life, like that of the lower plants. Lamarck accounts for this peculiarity by regarding their alimentary canal as constituting a second absorbing surface, in no way different from the absorbent external surface of the *Agastria*, or infusorial tribes, so that any portion separated from their bodies may live for a time, like the Infusoria, until they have obtained the second or internal absorbent surface.

"On considering," says Mr Macleay, "the gelatinous composition of these animals, the dispersion of the nervous molecules through their substance, and the absolute certainty that they are devoid of every sense, except perhaps those of taste and touch, we are led to connect them with the *Mollusca*, whose substance is always mucous, and often even gelatinous,—whose nervous system, though collected into several *ganglions*, or *centres of sensibility*, has nevertheless these ganglions dispersed, with little if any arrangement, throughout the whole mass of their body,—and whose senses, so far at least as we are certain of their existence, seem to be confined to those of taste and touch, with the exception of a few animals of the division which possess the organs of sight, and still fewer which possess those of hearing.

"Nevertheless, on comparing the *Acrita* with the *Mollusca*, we find that the organization of these last has become much more complicated, and that a distinct system of circulation, and peculiar organs for respiration, digestion, and secretion, are even visible in these animals, which connect them in a remarkable manner with a still more perfectly organized family—the *Vertebrata*.

"These, however, by their red blood, their muscular heart, their jaws acting vertically, their distinct organs for sight, hearing, smell, and taste, their sexes constantly distinct, their vertebral column, and extreme concentration of the nervous system, are sufficiently insulated from the *Mollusca*, as well as from all other material beings. The group is therefore perfectly distinct and natural; yet if we attempt to define it by any of the above-mentioned various properties, little examination is requisite to convince us that the characteristic thus chosen either disappears in the least perfect of the *Vertebrata*, or passes imperceptibly into the neighbouring groups.

"Thus in the fishes which compose the genera *Ammocætus*, Dum. and *Gastrobranchus*, Bl. all those parts which ought to have constituted their skeleton as vertebrated animals become so soft and membranaceous that they may be considered as having no bones. The organs of respiration and of manducation, the absolute want of the sense of sight, the general habits and external form of these singular fishes, all prove to us that they are connected with the *Annelides*, and that by them nature passes to the structure of the *Annulosa*. On the other hand, on examining some of the *Echinoderma* of Cuvier, such as those composing the genus *Comatula*, we may trace the articulated texture of the *Annulosa* into the division of *Radiata*, many of whose external forms are also exactly imitated by the sessile *Cirrhipedes*. Of the *Radiata*, again, the stellate form and the gelatinous semi-transparent substance are observable among the *Acrita*. So that the chain whose links we have endeavoured to unfold returns into itself, and we find that all animals form a circle composed of the following great divisions, viz.

Acrita,
Mollusca,
Vertebrata,
Annulosa,
Radiata.

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[1] "Animalia gelatinosa polymorpha, interaneis nullis medullâque indistinctâ. Os interdùm indistinctum, sed nutritio absorptione externâ vel internâ semper sistit. Anus nullus. Reproductio fissipara vel gemmipara, gemmis modo externis modo internis, interdum acervatis. Pleraque ex individuis pluribus semper cohærentibus animalia composita sistunt." (*Hor. Ent.* p. 224.)

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"This arrangement of animals is, it is true, quite distinct from that generally adopted; but it will be seen that it is not only conformable to nature, but that it removes many of the discrepancies which shock the naturalist in the common systems. For instance, there is an acephalous animal of the division *Mollusca* (*Ascidia mammillaris*, Linn.) which exists without any visible organs of sense except that of taste, whose substance is little better than a homogeneous gelatinous pulp, whose inert nature seems to deprive it of any power like that of voluntary motion; a being which is consequently reduced to fix itself to solid bodies, or to be the sport of winds and waves, whose principal sign of life consists in the absorption and spouting forth of water, and whose animal properties, in short, are all comprised in its irritability, its circulation, and respiration. Yet because these two last qualities appear in this animal, whose existence is little better than vegetative, to bear some resemblance to the circulation and respiration in some of the *Vertebrata*, we find it placed in the common systems before the bee, which astonishes us by its industry and social qualities; before the ant, which excites our admiration by its frugality and courage; and before the other numberless insects, which by their manners and stratagems have often made the naturalist hesitate as to the point where he would draw the line, and separate instinct from reason."[1]

Mr Kirby seems equally inclined to accord a step of precedence to the insect and other annulose or articulated tribes over the Mollusca, or at least to maintain that the latter should not be interposed between the former and the vertebrated tribes. "If you inquire," says he, "into the rank of each of these sub-kingdoms, of course you will assign the principal station to the *Vertebrates*, which are the most perfectly organized, to which man belongs, and over which he immediately presides. If we form the scale according to the nervous system of each province, that in which the organ of sensation and intellect is most concentrated will stand first; and in proportion as this organ is multiplied and dispersed, will be the station of the rest, which will place them in the order in which I have mentioned them; and the *Annulosa*, to which insects belong, will precede the *Mollusca*, which Cuvier and Lamarck had placed before them on account of their system of circulation. But when we reflect that a *heart* and *circulation* occur in some of the conglomerate *Polypi*,[2] animals that approach the *vegetable* kingdom; that some of the acephalous *Mollusca* have no visible organs of sense except that of taste, whose substance is little better than a homogeneous gelatinous pulp, and who seem from their inert nature to have very slight powers of voluntary motion;[3] we shall be convinced that a heart and circulation alone, unaccompanied by a more concentrated nervous system and more perfect structure, cannot place an animal above those which in every other respect so obviously excel them. With regard to *insects* particularly, we may further ask—who that considers how man employs his powers and organs even in his most degraded state, or that contemplates the wonderful works that he is enabled to accomplish when his faculties receive their due cultivation and direction, can avoid regarding him as superior to the rest of the animal creation? And what unsophisticated mind, not entangled in the trammels of system, when it surveys the industry, the various proceedings, and almost miraculous works that have been laid before you,—the waxen palaces of the bee,—the paper cottages of the wasp and hornet,—the crowded metropolis of the white ants,—the arts, the manufactures, and stratagems of other insects,—the associations and labours for the common good of those that are gregarious;—will not at once conclude that they must be a superior race to the slug, the snail, and others, which live only to eat and propagate their kind? Or who, that considers the wonderful structure of the animals whose cause I advocate,—the analogy that exists between their organs of manducation, of motion, and of sensation, and between various other parts of it, with those of the higher animals,—the acuteness of their senses, their wonderful strength of muscle, and powers of locomotion,—but will think them superior to the headless and almost inanimate oyster or muscle, or the conglomerate *Alcyonia*, though they have a heart and circulation. Who, again, that observes, that in proportion as pedate animals approach to the human type, their motions are accomplished by fewer organs,—that man walks, *ore sublimi*, upon *two legs;* the majority of quadrupeds upon *four;* insects upon *six;* the *Arachnida* apparently upon *eight;* most *Crustacea* upon *ten;* and the *Myriapods* and others upon *many*,—but will thence conclude that insects must precede the *Arachnida* and *Crustacea?* Who, once more, that reflects, that if any of the superior animals are deprived of a limb, it can never be reproduced, and that in insects the same circumstance occurs; while spiders and *Crustacea*, if they lose a leg, have the power of reproducing it; and the *Mollusca*, if they are decapitated, can gain a new head,—will consent to their being placed after any of these animals?[4] Lastly, who that recollects that the *Mollusca* are hermaphrodites, like most plants, bearing both male and female organs in the same body, but will allow that insects, in which the sexes are separate, as in the Vertebrates, must be more perfect, and of a higher grade?"[5]

Whoever regards the different classes of the animal kingdom with an observant and discriminating eye, will not fail to perceive that the knowledge of any organ in one particular division of nature is insufficient to enable us to judge of its importance; for such are the changes in the organization of animals, that a system of organs which performs the most important functions in the first division, may either not exist in the next, or be found in a secondary condition, and subordinate to some other system which has acquired the preponderance. In truth, the anatomy of the higher classes having been first profoundly, or at least laboriously studied, before the requisite attention had been bestowed on the structure of Invertebrates, all those organs and functional actions which were invariably more or less sustained and apparent in these first divisions, have been regarded as fundamental, and for this reason alone an equal importance in our systems of classification has been attributed to them throughout the whole animal kingdom. From this course of proceeding, as noticed by M. Straus, approximations have resulted which break the natural relationship of many divisions. For example, in the first great division of animals, respiration and circulation being in fact two functions to which all the rest are more or less subordinate, it has been imagined that we ought to regard them as essential in the whole series of animals, and employ them as the sole basis of classification. Among the Vertebrata these functions indeed afford the firmest foundation for a natural distribution; but amongst other classes, on the contrary, in which they are only secondary, their adoption has led to the

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[1] *Hor. Ent.* p. 202.

[2] Savigny, *Mem. sur les Anim. sans Vertèbr.* ii. 1, 3.

[3] *Hor. Ent.* 204.

[4] In this respect insects excel many reptiles, which can reproduce some of their parts.

[5] See Macleay, *Hor. Entomolog.* 203, 206, 298.

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gravest errors and most palpable contradictions; for it not unfrequently happens that one family of Invertebrata which respires by branchiæ, cannot be separated (keeping numerous natural affinities in view) from another family in which the respiration is pulmonary or tracheal.[1] One great principle of creation being to combine variety in the means with uniformity in the effect, we find that among molluscous animals the circulation of the blood varies in its manner *ad infinitum*, and has thus led to the most artificial arrangements. Yet few animals in existence have the organs of circulation more complicated than some of the Cephalopoda. Among the annulose animals, also, in which the nature of the nervous system is so uniformly accordant, circulation varies from an extremely perfect to an evanescent state. A mode of nutrition and respiration takes place so entirely different from that exhibited by the vertebrated and molluscous tribes, that they never can be regarded as modifications of the same system. As, then, the general plan of construction of these animals is so different, Mr Macleay regards it as necessary to suppose that the new and dissimilar system of respiration is that which more peculiarly characterizes the annulose group, or, in the author's words, "is that to which the structure of the animals forming the group tends." And what makes this supposition the more probable is, that the Annelides, or red-blooded worms, which, of all the articulated tribes, are placed by Cuvier the nearest to the vertebrated classes, are nevertheless imperfectly organized, and of as dull perceptions as any of the annulose division. This could hardly be the case were the Annulosa to be considered with propriety as modifications of the vertebrated structure, while, on the other hand, those annulose classes which respire by tracheæ, and coincide in nothing with a vertebrated animal, are, nevertheless, the most active and industrious of their group, although their activity and industry are of a nature entirely different from what is observable among the vertebrated tribes. Now it is difficult, if not impossible, to account for all this, unless we regard every vertebrated creature to have been constructed by the great Creator with reference to one type, and every annulose with reference to another; and as the former is more imperfect in proportion as it approaches the annulose structure, so the latter also becomes more imperfect in proportion as it obtains a distinct system of circulation and other characteristics of the vertebrated tribes. It thus follows that the animals which connect them ought to be extremely imperfect in their organization; and this conclusion is well supported by the sluggish Annelides, in which organs of sense are barely perceptible, and organs of motion by no means so perfect as among the larvæ of insects.[2] M. Straus also maintains the opinion that it is the less perfect species of any one great group which approach most closely to the group which precedes or follows them, and that it hence results, that in any division, the species which offer the most elevated organization may be more perfect than such as are placed at the lower confines of a higher division. He admits that a more natural passage exists from the Vertebrata to the Annulosa, than from the former to the Mollusca; but this connection he considers is by the lowest in the scale of organization of each of these groups. As soon as the Vertebrata reach the most simple form compatible with their mode of organic life, the great Author of nature commences from that point a new group, that named *Annulosa*, by successively introducing a new series of organs altogether different from those he has abandoned, and by considerably modifying those he has retained. The genus *Ammocœtes* (and perhaps also that of *Myxine*) form this point among the Vertebrata, while *Gordius* and *Hirudo* compose the corresponding link among the annulose tribes. On either side these animals find their place at the lowest point of the descending scale, formed by each of these two series; and, compared with each other, the two genera of fishes just named, and the abranchial *Annelides*, present some remarkable resemblances in the few organs which they possess.

The opinion that insects and other annulose animals are more nearly connected with the Vertebrata than are the Mollusca, is regarded as true by M. Straus Durckheim, both in regard to the modes of organization according to which these three divisions are formed, and in relation to the degree in which their faculties are developed. The Vertebrata, he observes, are characterized by an articulated body, of which the two lateral halves are symmetrical, and are sustained by an internal skeleton, the central portion of which is composed of a series of parts, to which the other osseous parts are attached. In the Annulosa the symmetry of the two sides of the body is still greater than in the Vertebrata; the body is likewise articulated, and formed by a series of central parts, to which the others are attached, although they have no internal skeleton. The nervous system in both consists principally of a spinal marrow, from which arise most of the nerves of the body; but there is this difference in the Vertebrata,—the spinal marrow is dorsal, whereas it is ventral among the annulose tribes. The muscular system is also as fully developed in the one as in the other, and offers nearly the same distinct forms. The Mollusca, on the contrary, exhibit characters totally at variance with those now mentioned; for, on the one hand, their body no longer exhibits a perfect parity of parts, nor is it in any degree articulated; on the other, the nervous system is not longitudinal, nor its situation constant, while its mass is greatly decreased. The muscular system is also in general much less perfect, and, considered in detail, the muscles are less distinct, and only form, throughout the greater part of the body, a mass of fibres so interlaced as to be incapable of separation, thus conducting us to *Entozoa*, of which the body is only a continuous *parenchyma* without distinct muscles. According to the author last named, the character which eminently distinguishes the Mollusca from the two other divisions is, that in these the organs of *animal*, in the Mollusca those of *vegetable* life, are the most predominant; from whence it follows that the latter are totally devoid of industry, and of that higher mode of perception approaching to *intelligence*, which insects possess in a degree surpassing all other invertebrated tribes.

Having entered into the preceding investigation with the view of illustrating the true position of the annulose division in relation to the other sub-kingdoms of animal life, we shall now, in more direct reference to the proper subjects of our present dissertation, that is, the hexapod or six-footed insects, exhibit, by means of the following diagram, the views entertained by Mr Macleay regarding the natural affinities observable among the annulose tribes themselves. The reader will perceive that the circles of *Mandibulata* and *Haustellata*, with those portions of *Ametabola* named *Thysanura* and *Anaplura*, constitute the true INSECTA, such as we have defined them at the commencement of this article.

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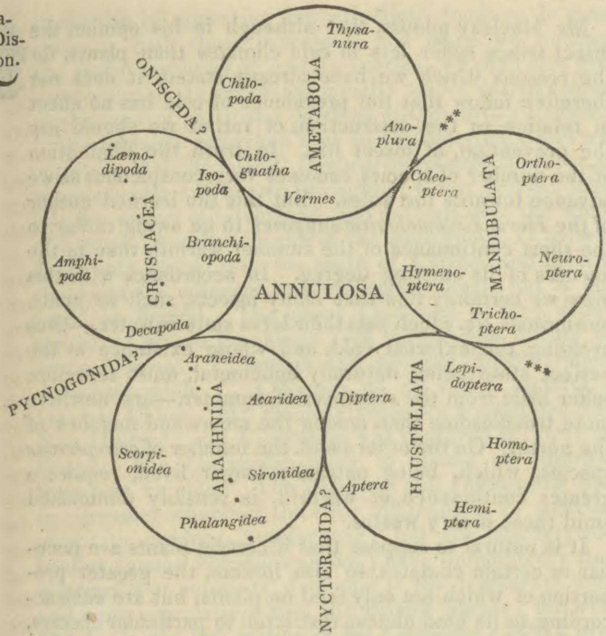
[1] See *Considerations générales sur l'Anatomie comparée des Animaux Articulés*, &c. par M. Straus Durckheim.

[2] *Hor. Ent.* p. 295.



Our next subject of consideration is one which has not previously formed a part of any of our encyclopædias of knowledge.

CHAPTER VI.

THE GEOGRAPHICAL DISTRIBUTION OF INSECTS.

This topic has indeed been much less attended to as a matter of philosophical investigation than it deserves. When we take an extended view of the general distribution of animals and plants, we find that they are usually disposed over the earth's surface in bands or parallel zones, corresponding in a great measure with the peculiarities of temperature and climate which are appropriate to the nature of each. When the temperature of a particular latitude becomes colder, as on mountains or highly elevated plains,—or warmer, as on plains by the sea shore, or in low lying sheltered valleys,—we find, in the former case, that the species approximate in their nature and characters to those of a more northern, in the latter to those of a more southern parallel. Of course the zones of vegetable and of animal life do not correspond at all strictly with the *latitudinal* lines of our geographical system. Humboldt has indeed shown, that within 15° or 20° from the equator, the mean annual temperature is nearly the same in all longitudes of equal elevation, or is at least but slightly varied by local circumstances. In other words, the isothermal lines are more regularly parallel with those of the equator. But in temperate and northern countries the same uniformity of temperature in each portion of the same parallel is not observable; all western coasts, and districts of continents and of considerable islands, being of a higher temperature than those of the same latitudes along the eastern shores. The mean temperature of the North Cape, under the seventy-first degree of north latitude, does not exceed, indeed corresponds with, that of Labrador, which is 14° further south; and that of the west of Ireland, in the fifty-fourth degree, agrees with the forty-third parallel in the United States.

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In relation to zoological geography, indeed, there are several other minor circumstances which tend to change or counterbalance the more usual results, and consequently to derange such calculations as might very reasonably be formed upon a knowledge of latitudinal and longitudinal position, and of the height of a country above the level of the sea. The nature of the soil and surface, the different degrees of dryness and humidity, and the consequent character of the climate and vegetation, the comparative extent of land and water, the extent and continuity of forests, marshes, and sandy deserts, the direction of mountain ranges, and the form and position of lakes;—these and several other circumstances must be taken into consideration, and will be found materially to affect the distribution of animal life over the surface of the earth.

It does not appear that the climates of insects, or those peculiarities of temperature and other physical attributes under which certain groups or species appear to predominate, have been as yet studied in connection with our imperfect knowledge of isothermal lines. Humboldt, indeed, has remarked, that the geographical stations of the gnats and some other insects of South America did not appear to depend solely on the *heat* of the climate, the excess of humidity, or the thickness of the forests, but on local and unappreciable circumstances.[1] It is evident, however, that the characteristic stations of insects are mainly dependent on the degree of temperature, so influential on the development and distribution of all the other varied forms of animal life. An increase of caloric seldom fails to produce a corresponding increase and alteration in the number and character of entomological forms; and when we travel from the hyperborean regions towards the sunny south, we find that the tiny multitudes accumulate in all the warmer portions of the temperate zone, till they swarm between the tropics. Otho Fabricius resided six years in Greenland, and during that period he collected only sixty-three species of the insect class, properly so called. In the still higher latitude of Winter Harbour, where Sir Edward Parry sojourned, only six species were collected from the beginning of September till the August following. Mr Kirby has stated that in Greenland every order of insect has its representatives, except Orthoptera and Hemiptera; but in Melville Island, besides these deficiencies, neither coleopterous nor neuropterous species exist, or at least were observable; and even the mosquito, that shrill tyrant of the Lapland plains, appeared to have ceased from troubling along those hyperborean shores. The most northern locality of any insect yet ascertained is that of the *Aphis borealis*, taken in latitude 82° 26′ 44″, about one hundred miles from the nearest known land.[2] It is probable, however, that the distribution of many northern species is still unknown. It was formerly supposed that in Iceland there were none, and that even in Norway there were very few, their absence from those countries being attributed to excess of cold. This opinion, however, was contradicted by Horrebow, so far as Iceland was concerned; and Olafsen and Povalsen, during their sojourn there, collected 200 different species in one small valley. It must indeed be borne in mind, that insects can escape the extreme of cold, not only, as Mr Macleay observes, by passing certain periods in the *pupa* or torpid state, but also by being while in that condition usually buried in the earth, where they are greatly protected from the rigours of the winter season. "What they chiefly re-

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[1] *Personal Narrative*, vol. v. p. 88.

[2] This species was found in the boat during the last day of Sir E. Parry's attempt to reach the north pole over the ice. There was no vestige of vegetation around the adventurous party; and we think it more probable that the forlorn insect had been carried, *nolens volens*, from a somewhat more southern quarter.

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quire is the presence of heat during some period of their existence; and the greater, within certain limits, is the heat, the more active will be their vital principle. On the American continent the extremes of heat and cold in the course of the year are, as is well known, incomparably greater than in places of the same latitude in Europe. We may therefore readily conceive how particular families of insects will inhabit a wider range of latitude in the former country than in the latter. We see also how insects may swarm in the very coldest climates, such as Lapland and Spitzbergen, where the short summer can boast of extraordinary rises in the thermometer; because the energy of the vital principle in such animals is, within certain limits, proportionate to the degree of warmth to which they may be subjected, and escapes in a manner the severe action of cold."[1] It is on these principles that Mr Macleay accounts for what certainly at first seems an extraordinary circumstance in the geography of insects; namely, that their tropical structure extends much farther north in America than in Europe; that is, in a manner directly the reverse of that which has been noted by botanists to occur in the vegetable kingdom. For example, the *Chamærops humilis*, a species of palm, occurs along the southern shore of France, in latitude 44°; while on the eastern coasts of North America the hardiest of the family, *C. palmetto*, does not advance beyond the 34°. But if we examine *Copris carnifex*, *Cetonia nitida*, *Rutela* 6 *punctata*, and other coleopterous insects from the neighbourhood of New York, and compare them with species of the same families from Brazil, we shall find their difference of structure infinitely less than that which would result from a comparison of the entomological productions of the environs of Madrid with those of the banks of the Congo.[2]

A slight consideration of the subject suffices to show that certain differences in the relative intensities of summer and of winter must exercise a strongly modifying power on the influence of mean annual temperature, even in countries where that temperature is one and the same. "Several fruits, as the olive and grape, as well as the different kinds of corn and other annuals, depend more on the heat of summer than of the whole year; while others, impatient of cold, and not requiring great heat, have their range more influenced by the temperature of winter. Now, it is almost an universal rule, that of two places whose mean temperature is the same, that nearest the sea, and more particularly a western sea, has a temperate summer and a milder winter. Hence the inland situation is better adapted to the growth of corn and fruits, the maritime one to the preservation of tender plants. In Europe, the northern boundary of the vine and olive rises as we go eastward, though in so doing we encounter a lower mean annual temperature. The *Arbutus Unedo*, *Sibthorpia Europæa*, *Erica ciliaris*, &c. rise in a westerly direction."[3] Whatever vegetation requires the absence of extreme cold rather than the presence of extreme heat, will probably extend itself in a tropical form more towards the poles on a dry continent than on a moist or marshy one. Tropical plants, therefore, will thrive better in Thibet and other inland parts of northern Asia, than they would do if transported to positions of the same latitude in America; for in the latter country the extremes of heat and cold are too distant from each other. Thus the vegetation of Canada does not correspond either in its general character or its amount of species, with that of the corresponding latitudes of France.[4]

Mr Macleay admits, that although in his opinion the insect tribes suffer less in cold climates than plants, for the reasons which we have already stated, it does not therefore follow that the prevalence of cold has no effect in relation to the destruction, or rather we should say the prevention, of insect life. In truth the diminution of the number of species becomes very conspicuous as we advance towards the poles. But this the learned author of the *Horæ Entomologicæ* supposes to be owing rather to the short continuance of the summer warmth than to the lowness of its existing degree. In accordance with this view we certainly find that many insects, such as gnats, mosquitoes, &c. which pass their larva state in water,—thus avoiding the external cold, and whose existence in the perfect state being naturally ephemeral, must therefore suffer little from the shortness of summer,—are nowhere more troublesome than among the moors and marshes of the north. On the other hand, the number of *coleopterous* species, which, being naturally longer lived, require a greater continuance of warmth, is sensibly diminished amid those dreary wastes.

It is natural to suppose that if certain plants are peculiar to certain climates, so also insects, the greater proportion of which not only feed on plants, but are each according to its kind almost restricted to particular species, must in like manner be characteristic of special localities. Whether this restriction in diet holds good in relation to the carnivorous kinds, that is, whether one kind of carcass is not as good as another, is a point which has not yet attracted the consideration of the naturalist. Such as feed on living animals (the *thalerophagous* Carnivora) are probably more restricted in their parasitical attachments. But the coprophagous or dung beetles, and such as prey on dead animals (the *saprophagous* Carnivora), may be supposed to be less regular in the limits of their localities, occurring wherever their favourite food happens (not seldom accidentally) to have been deposited. In such cases, of course, less advantage results to the entomologist from local references, as the appearance of an insect in the place cited may have been entirely accidental, and incapable of affording any great probability of its recurrence; yet even the saprophagous beetles are no doubt regulated by temperature and elevation, and it is likely that a dead body by the sea shore will exhibit different species from a similar nidus exposed on a mountain summit.

The geographical distribution of insects in general is, in truth, a subject of too difficult and complex a nature to admit of being worthily treated within our present limits. We shall, however, notice a few facts which, though presented in a somewhat desultory manner, we trust will not be found entirely devoid of interest.

We may observe, in the first place, that there are two aspects under which the subject of zoological geography may be viewed. We may either proceed upon the consideration of the divisions laid down by politico-geographical writers,—divisions which are no doubt sufficiently arbitrary in relation to the physical qualities of countries,—and describe or indicate the species and genera which we have ascertained to characterize such divisions,—or we may take into view the systematic arrangements of naturalists, and by tracing and pointing out the different localities of the various tribes, genera, and species which we find there arranged, thus arrive by another route at the conclusions sought for. We shall here, even at the risk of appearing immethodical, combine, in some measure, both these processes; and while we indicate the varied localities of certain species, we shall also give an occasional sketch of the equally varied entomological productions of particular portions of the earth's surface.

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[1] *Hor. Ent.* p. 45.

[2] *Ibid.*

[3] Watson's *Outlines of the Geographical Distribution of British Plants.* (Printed for private circulation.) Edinburgh, 1832.

[4] *Hor. Ent.* p. 44.

We formerly remarked that no coleopterous insect was noticed in Melville Island. *Dytiscus marginalis*, however, an aquatic beetle well known throughout Great Britain, inhabits the waters of Greenland, and extends over the whole of Europe. Another species of the same genus, *D. griseus*, is not only spread over the south of Europe, and most of the countries adjacent to the Mediterranean, but is also found in Bengal. The genus *Calasoma* is very widely spread. Captain Frankland took *C. calidum* during his arctic journey. *C. laterale* and *curvipes* inhabit tropical America; while *C. Chinense*, as its name imports, is found in China. Mr Macleay possesses a specimen from New Holland; and *C. retusum* was captured in Terra del Fuego. The *Coccinellæ* occur in almost all countries from pole to pole.[1] The *Silphidæ* and *Dermestidæ* prey on carcasses wherever the solar influence is of sufficient power to produce putrescence; but the brachelytrous beetles (genus *Staphylinus*, &c.) have undoubtedly their metropolis or centre of dominion in the temperate zone, and more especially within the British islands; for while Dejean, in the last edition of his *Catalogue* (1833), gives only 789 species as his total amount both of European and exotic kinds, Mr Stephens enumerates above 750 as indigenous to Britain. This apparent excess may, however, partly arise from the great attention which has been paid in this country to the collection of the minuter sorts, which are frequently neglected in foreign lands for the sake of the more showy and imposing species. The genus *Onthophagus* is native both to the old world and the new, to the temperate as well as the torrid zone; while *Copris*, its near ally, is more abhorrent of cold,—*C. lunaris*, which extends northward into Sweden, being the only recorded species found in Europe out of Spain.[2] Latreille, however, laboured under a misconception when he supposed that all the large species of the latter genus were of equinoctial origin; for *C. Tmolus* of Fischer occurs in the vicinity of Orenburg in Asia, under the 50th degree of north latitude.[3] Of the magnificent *Dynastidæ*, termed by Mr Kirby the "giants and princes of the insect race," the metropolis is strictly tropical, although a kind of advanced piquet is observable in *Oryctes nasicornis*, common in the south of Sweden. The reason why the last-named insect, and several others which occur in Scandinavia, are unknown in Britain, may be inferred from some of our preceding observations: in a torpid state, or under the form of larvæ, they are capable of enduring the utmost rigour of a Swedish winter; but when revived by the returning spring, the cool and variable summers of our "sea-girt isle" would prove insufficient for the full development of their vital functions.

The genus *Meloe* seems almost peculiar to Europe; and Britain, which possesses nine species, has been regarded as one of its most characteristic countries. The entomological characters of the southern shores of Europe strongly exhibit their geographical approach to the African continent. The *Ateuchus sacer* (the renowned species sculptured of old by the Egyptians on their sacred monuments), and various species of *Scaurus* and *Akis*, may be regarded in the southern countries of Europe, as the *avant couriers* among the coleopterous tribes of those more exclusively African forms which have their centre of dominion in the burning deserts. Along the Mediterranean shores the entomological traveller may study the habits of many curious insects of the genera *Onitis*, *Cebrio*, *Pimelia*, *Brachycerus*, *Brentus*, and *Scarites*, and may also enrich his collection by the capture of many beautiful butterflies, and other lepidopterous insects, which are more truly characteristic of Northern Africa. Spain especially exhibits many features of African zoology. We shall not here talk of the cameleons, the scorpions, and other species belonging to the separate classes of reptiles and Arachnides; but the European entomologist will there discover for the first time several species of the genera *Erodius*, *Sepidium*, *Brachinus*, and *Pimelia*. It is however only after crossing the Mediterranean, and traversing the African shores, whether north of the Atlas, or eastward towards the coasts of the Red Sea, that our eyes are delighted with the hitherto unknown forms of *Anthia*, *Graphipterus*, *Siagona*, and numerous other species unknown to the colder and moister shores of Europe.

But no sooner do we leave the Mediterranean coasts of Africa, and enter upon the more weary and disastrous pilgrimage of the great deserts, the apparently limitless expanse of which so soon greets the eye of the yet undaunted traveller, than almost all vestiges of European life, whether human or brute, disappear; and Nubia, Ethiopia, Senegal, and a great part of Guinea, exhibit entomological forms, cognate in character when compared among themselves, but separated in every sense of the words "*longo intervallo*" from those of Europe. As we proceed farther southwards, where the chariot of the "Great Apollo" rolls on with a still fiercer and more fiery lustre, and the beams of a vertical sun induce even the tawny Moor and the woolly-headed negro to avoid his scorching and sometimes fatal rays, we discover many extraordinary forms of insect life, called into existence through the instrumentality of that bright effulgence which the pale-faced European has so often sought to withstand in vain. From the burning regions of Guinea, and the parched shores of the Congo, we derive the finest of those magnificent coleopterous insects named generically *Goliathus* by Lamarck. The western and equinoctial parts of Africa also yield us the species of *Petalocheirus* and *Enceladus*, while the Cape of Good Hope is remarkable for the genera *Anthia* and *Brachycerus*. The last-named district is almost the exclusive domain of *Manticora* and *Pneumora*; and the southern parts of Africa present us with the *Sagra*, *Diopsis*, and *Paussus*, although it may be observed that some of these also occur in the East Indies.[4]

Both Madagascar and St Helena present a few insects which, to a certain extent, demonstrate the African complexion of those islands; but the latter especially is also allied, by its entomological features, to some of the south-western countries of Asia. According to Latreille, Africa furnishes no species of the genus *Passalus*, although it is elsewhere widely distributed over America and the East Indies. The genera *Graphypterus*, *Eurichora*, and *Pneumora*, are probably peculiar to Africa. Among the hemipterous insects of Africa may be mentioned the *Mantis precaria*, an object of superstitious veneration among the Hottentots, who hold in the highest respect the person on whom the insect happens to alight. Locusts are of common occurrence in many parts of Africa, where, as "a great people and a strong," they still produce their days of "darkness and of gloominess," their days "of clouds and of thick darkness," so magnificently described by the Prophet Joel. One of the most formidable of the insect tribes of this continent is the *Termes bellicosus*, or

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[1] *Introd. to Ent.* vol. iv. p. 488.

[2] *Ibid.* p. 490.

[3] *Entomographia Russica*, tab. 13, fig. 1.

[4] *Edinburgh Cabinet Library*, vol. ii. p. 93.

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white ant. It dwells in congregated troops, consisting of labourers, soldiers, and sovereigns. The habitations are of a conical form, built of mud and clay, from ten to twelve feet high, and divided in the interior by thin partitions into a variety of cells. Indeed, Jobson, in his *History of Guinea*, alleges that they are often twenty feet high; and he adds, that he frequently found them extremely serviceable in screening himself and his companions while engaged in the pursuit of antelopes and other game. The queen-mother of this species becomes of so enormous a size in the pregnant state, that her abdomen exceeds, by two thousand times, the bulk of the rest of her body; and when the ova are fully formed, she obtrudes them at the rate of sixty in a minute, or 72,000 in twenty-four hours. Madeira and the Canary Islands are decidedly African in their productions,—the insects, especially, exhibiting a strong relationship to those of Barbary and the adjacent districts.

Latreille, while considering the geographical distribution of insects, has well observed, that where the empire of Flora terminates, there the domain of zoology likewise comes to an end. Animals which feed on vegetables cannot support themselves in a region entirely sterile, and such as are carnivorous are thus themselves indirectly deprived of sustenance in consequence of the want of vegetation. Those countries of which the vegetable productions are the most gorgeous and abundant, are likewise the most productive of insect life. Both effects spring from a temperature high and continuously sustained, from moderate moisture, and a varied soil. The more closely, on the contrary, we approach the other extreme, where clouds and darkness obscure the sky, and the ground is so often covered with a pure but unproductive garment of snow, and the lifeless solitude of the mountain valleys is defended by the icy battlements of the enduring glaciers,—the more we shall perceive a diminution in the amount of organic, and more especially of insect life. If, instead of travelling northwards to the polar plains, we ascend some majestic mountain even of a tropical range, the same phenomena are observable. Although its base should be laved by the glittering waters of an equatorial sea, and its sloping sides should bear the arborescent ferns and plumy palm trees of the warmest climes,—still, should the mountain belong to the highest class, like those of Cayambé or Chimborazo, long before the traveller has approached its barren summit, he will perceive the most striking symptoms of that sterility which we are apt to associate only with the polar regions. The "bright consummate flowers" of the lower plains have disappeared,—the parrots in their gay attire no longer adorn the stunted trees,—and the insect tribes, so fantastic in their forms, and of such surpassing lustre, have gradually decreased in size and number, and at last present, in common with the vegetable kingdom, an aspect and character much more allied to those of northern climes. Finally, unless it may be that some giant condor, or other bird of loftiest flight, is seen floating in the thin air of those extremest heights, there is nothing to remind the adventurous traveller that he is actually within the *burning* tropics; for all his perceptions and sensations might be identical were he suddenly transported to the summit of Mount Hecla,

> An earthquake-rifted mountain of bright snow.

It is thus that, on the Central Alps of Europe, we meet with many species characteristic of, though not peculiar to, the plains of northern countries. The *Prionus depsarius*, long regarded as exclusively confined to Sweden, has in later times been taken on the mountains of Switzerland; and M. Latreille has captured at Cantal the *Lycus minutus*, formerly received only from the most northern provinces of Europe. The beautiful Apollo butterfly (*Parnassius Apollo*), so common in the plains and flower-gardens in the vicinity of Upsal, never occurs in France, except on mountains of considerable elevation, and re-appears again in the snow-surrounded valleys of Switzerland. Many other butterflies which, in the northern provinces of France, occur not far from warm and low-lying sheltered stations, are found in the southern departments and in Italy on alpine or sub-alpine situations. The same may be said of *Carabus auratus* and *Acridium grossum*. Even in Great Britain, the limited extent of which might be supposed to preclude any great disparity in the entomological productions of its geographical divisions, there is an obvious difference between its southern and northern quarters. The colder and more cloudy clime of Scotland is poor in Lepidoptera of the finer kinds. Here no purple emperor, "proud of cerulean dyes," floats over the far-stretching branches of our oaks and beeches,—no swallow-tailed butterfly (*Papilio Machaon*), with its elegantly lengthened wings, reminds us of the exquisite Brazilian tribes,—no "Camberwell beauty" (*Vanessa Antiopa*) expands to the sun its richly margined wings; but these and many more, denied to bleak Caledonia, are found in the southern counties of England.[1] It is interesting, however, to observe the analogy which exists between the insects, more especially the Coleoptera of Scotland and of Sweden. Several of the rarest species lately discovered in the northern quarters of the island, such as *Clivina Arctica*, *Harpalus micropterus*, *Elaphrus Laponicus*, *Byrrhus æneus*, *Salpingus foveolatus*, and others, are better known in the Scandinavian peninsula than elsewhere, and are indeed characteristic of the north-western division of the continent of Europe.

From these and similar observations, those who have viewed the science of entomology with a philosophic eye have endeavoured, in common with geographers, to divide the surface of the earth into different climatic regions. But while the latter have assumed as a basis the progressive differences in the longest continuance of the natural day, the former proceed upon a knowledge of the mean temperature of countries. Fabricius, in his *Philosophia Entomologica*, divides climate in general into eight subclimates, or restricted stations, viz. the *Indian*, the *Southern*, the *Mediterranean*, the *Northern*, the *Eastern*, the *Western*, and the *Alpine*. But it is easy, as M. Latreille has remarked, to perceive, by the enumeration of the particular countries which are referred to each of these divisions, that the divisions themselves are by no means established on a fixed foundation; and that the suppression of several would be necessary were the principle on which they are established followed out with rigour. The subclimate which he names *Mediterranean* comprises the countries adjacent to the Mediterranean Sea, with Media and Armenia. The *Northern* extends from Paris to Lapland. The *Eastern* consists of the north of Asia, of Siberia, and of the cold or mountainous portion of Syria. The *Western* contains Canada, the United States, Japan, and China. From these it will be seen that this arrangement is in many respects extremely arbitrary; for several of the above-named districts, although placed under separate climates, have a mean temperature identically the same. Moreover, many countries in which the mean temperature is the same, are characterized and distinguished

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[1] On the other hand, *Hipparchia Blandina* and *Lycæna Artaxerxes*, two extremely rare English butterflies, occur very plentifully in many parts of Scotland,—the former in July and August, the latter in June and July.

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by a great disparity in the nature of their animal productions.

M. Latreille has taken another view of this interesting subject, more in conformity with the dictum of Linnæus, regarding the characters of genera, the spirit of which may be also here applied. "Let the insects point out the climate, and not the climate the insects." He takes into consideration all those genera which seem to be appropriated exclusively to certain determinate spaces on the surface of our earth. It is true that the groundwork of this method is much more restricted than that from which Humboldt and other writers on botanical geography have deduced their observations on the distribution of plants; for our knowledge of the precise localities of foreign insects is by no means ample.[1] The great French entomologist rather upbraids the majority of scientific travellers with their negligence in these particulars; for it is not the locality alone, but the physical character of the climate, the mineralogical qualities of the soil, the vicinity of wood and water, and the height above the level of the sea, which ought to be noted in connection with the occurrence of particular species. We have already noticed the fondness of *Papilio Cleopatra* and other insects for a calcarcous soil. The *Pimelia bicaudata*, so common in the neighbourhood of Marseilles, scarcely ever occurs at a distance from the sea. If the interior parts of Barbary, Syria, and Egypt, present us with species of the same genus, this entomological relation no doubt results from the soil of these countries being impregnated with saline particles, and abounding in plants of the genus *Salsola.* The insects which occur in the countries which border the Mediterranean, the Black, and the Caspian Seas, exhibit many analogies.

The following propositions result from M. Latreille's researches in Entomology.

1*st*, The totality or a great proportion of the insects which occur in countries of which the qualities of the soil and temperature are analogous, are nevertheless of different species, if these countries, though placed under the same parallel, are widely distant from each other. All the insects brought from the most eastern parts of Asia, for example China, are distinct from those of Europe and of Africa, whatever may be the latitude, elevation, or mean temperature of these Asiatic countries.

2*d*, The generality of insects still differ specifically in countries agreeing in the characters of their soil and temperature, but separated, independently of mere latitudinal difference, by great natural barriers, such as chains of lofty mountains, vast sandy deserts, or the waters of an intervening ocean. Thus the species of New Holland or of America are easily recognised among those of the various countries of the ancient world; and even the insects of Grenada and Peru, though at no great distance from those of Guiana, are in a great measure different, owing no doubt to the interposition of the vast chain of the Cordilleras. When we pass from Piedmont into France by the Col de Tende, we perceive a marked difference of species, even in that short journey. These rules, however, like most others, however general, are subject to several individual exceptions. Several species of insect are distributed over such a vast extent of territory as entitles them to be regarded as genuine cosmopolites. Thus the painted lady-butterfly (*Vanessa Cardui*) is found over great portions of Europe, Asia, Africa, and America, and is as familiarly known in the central islands of the vast Pacific Ocean, as in the flower-gardens of England.[2] That beautiful sphinx-moth (*S. nerio*), well known near Genoa, and so remarkable for the richness of its *green*, a rare colour among lepidopterous species, although it seldom occurs farther north than France, is found in the Mauritius, and probably in many intermediate countries. The deaths' head moth (*Sphynx Atropos*), which occurs occasionally in most parts of Scotland, is well known in India and the Isle of France. We have already mentioned the great extent of territory occupied by several aquatic beetles; and these and other examples which might be adduced remind us of M. Latreille's next proposition.

3*d*, Many *genera* of insects, and particularly such as feed on vegetables, are spread over numerous points of the principal divisions of our globe.

4*th*, Other genera are exclusively proper to a certain extent of country, whether of the ancient continents or the new. According to Latreille, no species of the genera *Anthia, Graphipterus, Erodius, Pimelia, Scaurus, Cossyphus, Mylabris, Brachycerus, Nemoptera, Apis*, or *Anthophora*, occur in America; and many genera of the family *Scarabeidæ* are likewise there unknown. But the western world, on the other hand, produces several genera which we do not meet with elsewhere,—such as *Agra, Galerita, Nilio, Tetraonyx, Rutela, Doryphora, Alurnus, Erotylus, Cupes, Corydalis, Labidus, Pelicinus, Centris, Euglossa, Heliconia, Erycina, Castnia*, &c. Our bees are there replaced by *Melipona* and *Trigona*. We have already mentioned several genera peculiar to Africa. *Colliuris* is characteristic of the East Indies; *Lamprima, Helæus, Paropsis* (*Notoclea* of Marsham), and *Panops*, are confined to New Holland.

5*th*, Many species in their natal countries effect particular localities. Several alpine butterflies are never observed at any considerable distance from the region of perpetual snow, while other species prefer the warmer air of low-lying sheltered meads at no great height above the level of the sea.

6*th*, Both the ancient continent and the new may be divided into zones, successively extending in the direction of the meridians, and the breadth of which is measurable by a portion of a circle parallel to the equator. The species proper to one of these zones disappear gradually, and give place in the same manner to those of the zone following; so that from space to space the dominating species, or even the totality, have undergone a change.[3] Latreille compares these changes to that series of horizons which the traveller discovers in proportion as he removes from his first point of departure.

Sweden presents us with many insects peculiar to that country, some of which are confined to its more northern provinces, such as Lapland. But its southern portions, for example Scania, produce, though still in limited numbers, many German insects. France, as far as the 45th or 44th degree, supplies the entomologist with many of the species which occur in the last-named countries; but the Rhine and its eastern mountains form a kind of frontier line, which many others do not appear to pass. The first of the species characteristic of the warmer regions of

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[1] The second edition of Comte Dejean's *Catalogue de Coléoptères* now exhibits a very interesting picture of the distribution of that order. We shall refer to it more particularly when we come to treat of the coleopterous tribes.

[2] *Edinburgh Review*, vol. liii. p. 339.

[3] *Introduction à la Geographie Gènèrale des Arachnides et des Insectes, ou des Climats propres à ces Animaux.* This memoir was read to the Academy of Sciences in 1815, and forms part of the 3d volume of the *Mémoires du Muséum d'Hist. Nat.* It was afterwards republished, with corrections and additions, along with some other essays, in a separate volume, entitled *Mémoires sur divers Sujets de l'Histoire Naturelle des Insectes*, &c. Paris, 1819.

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Western Europe show themselves towards the inferior course of the Seine, in pretty close accordance with the point where the vine is vigorous in the open air, independent of any succour derived from merely local circumstances. *Ateuchus flagellatus, Mylabris chicorii, Mantis religiosa, Cicada hæmatodes, Ascalaphus italicus,* and others, announce this change,—which becomes still more obvious at Fontainebleau and the environs of Orleans, where, in addition to the above-named species, we may perceive *Phasma Rossii, Mantis pagana,* and *Sphinx celerio.* But these are but the forerunners of such as are native to southern countries properly so called. The culture of the olive, the spontaneous growth of the Arbutus, the pomegranate, and of lavender, are botanical symptoms which cherish in the mind of an instructed entomologist the hopes of a rich increase. This change is very obvious in France, when, journeying from Paris to Marseilles, we reach the territory of Montélimart. The eastern provinces of Spain, those sunny regions where the orange and the palm-tree are luxuriant without the aid of man, produce more abundantly the rarer southern insects of France, intermingled with species hitherto unperceived in Europe.

Our knowledge of the insects of the south-east of Europe is by no means ample. Latreille informs us that the *Papilio chrysippus* of Linnæus, common in Egypt and the East Indies, makes its first appearance as a European species in the kingdom of Naples. The greater proportion, however, of the Egyptian species are entirely unknown in Europe, although they pertain, in numerous instances, to the same natural families as our own. The southern parts of that land of pyramids produce many magnificent species of *Copris,* such as *C. Midas, Bucephalus, Antenor, Gigas,* and other insects peculiar to warm countries, and seldom found at any great distance from the equinoctial line of the old continent.

Similar successions of species take place from east to west, and reciprocally. Most of the insects which occur in Normandy and Brittany likewise inhabit the southern parts of England. The northerly departments of France, situated on the banks of the Rhine, have in many respects a community of species with the neighbouring provinces of Germany; while, again, several species of the Levant, such as *Cantharis orientalis, Mylabris crassicornis,* a beautiful variety of *Melolontha occidentalis* brought home by Olivier, and certain diurnal Lepidoptera, appear to have journeyed far westward from their ancestral homes, and fixed their abode in the Austrian territory. The collections formed by Olivier in Asia Minor, Syria, and Persia, prove that the insects of those countries, though nearly related to those of the south of Europe, are not specifically the same; and a like judgment, with some exceptions, may be entertained of the species of Southern Russia and the Crimea. The entomological productions of the coast of Coromandel, of Bengal, of the south of China, and even of Thibet, possess many characters in common; but they are entirely distinct from those of Europe. In the regions just named we discover no species of the genera *Graphipterus, Akis, Scaurus, Pimelia, Sepidium,* or *Erodia,* for of these nature appears to have granted the exclusive possession to the south-western regions of the ancient continent. Although Fabricius assigns the East Indies as the native country of certain species of *Brachycerus,* Latreille has been unable to identify any from such locality. The genus *Anthia* is said to occur in Bengal, but not farther eastward.

The great Asiatic division of our globe, when considered in its entomological and other zoological relations, may indeed be partitioned into several different departments.[1] The Siberian or most northern portion, in consequence of the severity of its winter season, possesses, even in its southern districts, many attributes of the arctic regions; while its inland valleys, and the upper basins of its numerous and far-flowing rivers, are enriched, during a brilliant though short-lived summer, with many of the more gorgeous forms of insect life. Another vast and imperfectly known region of Asia is bounded to the north by Siberia, and to the south by those highly elevated table-lands which terminate among the Himalaya Mountains. This division still presents several features which prove its assimilation in some respects to the characters which distinguish animal life in Europe; for although it is undoubtedly characterized by numerous peculiar forms of existence, yet many of its genera and species are either the genuine types of groups which occur in countries with which we are familiar, or pertain to groups which are themselves well exemplified by European insects. But we now speak rather in relation to the higher animals than the insect tribes; for, in truth, of the Entomology of Central Asia we have as yet a most inadequate idea. Among the Himalaya Mountains, and other southern portions of this division, we begin to discover many genera of birds which occur in the lower lands of Hindustan and the peninsular projection of Malacca; and if the entomological kingdom is at all regulated by corresponding rules, we may infer that some of the southern insects also make their way up those stupendous valleys. The same circumstance indeed occurs, we mean the like transition of species, in all the great geographical sections of the groups of animal life. "Each extensive division is characterized by several peculiar forms, and yet at the same time nourishes many species which are common alike to it and to other regions; and it is only under some peculiar circumstances of local situation, that either the zoological or botanical products undergo a sudden change in character and condition. As the adventurous and observant traveller advances on his journey, a few species are continually perceived to decrease in number, and then to disappear, while their places are supplied by others, which, at first but thinly scattered, gradually acquire an accession of numbers, till they too have reached their full amount or centre of dominion; but the change being only partial from place to place, the difference is no more suddenly perceptible than that in the horizon by which the traveller is surrounded, and a portion of which in his onward progress becomes insensibly, from the circumference, the very centre of the field of vision."[2] But no sooner do we enter upon the zoology of India Proper, than the European forms of animal life almost entirely disappear, and are succeeded by others of a richer and more varied character of form and aspect, some of which, however, extend to the parallel latitudes of the African continent. The Asiatic Islands again present us with another picture, and this latter change may be said to commence at the southern extremity of the Isthmus of Malacca. Java and Sumatra, in Mr Swainson's opinion, will probably be found to be the metropolis or central region of this range, which still produces several of the forms of Northern India; while in New Guinea and New Ireland, the Asiatic forms properly so called begin to disappear, and are replaced by many singular and interesting species, which exhibit the commencement of what may be termed the Australian kingdom. *Papilio bolina* occurs both in Java and New Holland.

Madagascar, as might be supposed, exhibits in its natu-

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[1] *Edinburgh Cabinet Library*, vol. viii. p. 1.

[2] *Ibid.* p. 2.

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ral families a resemblance to Africa. Nevertheless the species are distinct, and many of them present no analogy whatever to those of the continent. The Isles of France and Bourbon likewise manifest traces of the same family resemblance; but, on a general view, they show a closer connection with the East Indian species. Their ascertained number is, however, extremely limited.[1]

Although the Entomology of New Holland may be said, like that of all other vast tracts of country, to exhibit a special type, it is yet composed, in some of its principal portions, of species analogous to those of the Moluccas and the south-east of India. This great fifth continent, as it has been called, is, however, less rich in insects than many other foreign countries, its soil being drier, and not so well wooded. The genus *Mylabris*, so abundant in the south of Europe, in Africa, and Asia, does not appear to pass beyond Timor. In that respect, then, New Holland agrees with America, as well as in the possession of *Passalus*, a genus of which the species have been more particularly noted as inhabitants of the new world. Several generic groups of the latter region present a closer resemblance to those of the east of Asia, than to such as are characteristic of the ancient world. The insects of New Zealand, of New Caledonia, and the circumjacent isles, show an obvious relation to those of New Holland; and the same may be said of such as occur in the archipelagos of the Great Southern Ocean. These islands, composed in great measure of aggregations of polypiferous rocks, form a chain which unites them in a westerly direction to the preceding regions, and from which many of their natural productions may have been received in the long course of ages. This natural communication could not have taken place with the new world, and thus many of these islands, although rather American than otherwise, according to their geographical position, may be regarded as Asiatic in regard to their animal and vegetable products.

The new world has also been observed to present progressive changes in the succession of its species, in connection with every considerable difference in the latitude and longitude. M. Bosc collected in Carolina many species which were unknown in Pennsylvania, and were still more foreign to New York; and the researches of Abbot in illustration of the Lepidoptera of Georgia demonstrate the existence in that province of certain species which have their central station in the Antilles. The banks of the far-stretching Missouri, about twenty degrees to the west of Philadelphia, produce many peculiar species. The Entomology of the Antilles presents a strong contrast to that of the United States. Trinidad, under the tenth degree of north latitude, presents us with truly equatorial species, such as the splendid butterflies called Teucer and Menelaus, which do not occur in St Domingo. Brazil, so gorgeous in its insect tribes, possesses species in common with Cayenne, but it also produces many others peculiar to itself. Latreille differs from Mr Macleay in his opinion regarding the comparative extension, in a northerly direction, of the southern species in the new and old world. He states that the southern species of the western hemisphere do not attain to so high a latitude as they do on the ancient continents. Here, he thinks, they begin to appear between the forty-eighth and forty-ninth degrees of north latitude; there, not until we gain the forty-third degree.[2] In relation to this subject Mr Kirby has remarked, that although the winters in Canada, within the same parallel as France, are longer and more severe than those even of Great Britain or of Germany, yet the summers are intensely hot; so that though tropical *species* do not range so high, those of a tropical *structure*, in conformity with Mr Macleay's views, may be found in a higher latitude in the new world than in Europe.[3] When we take into consideration certain peculiarities in the physical constitution of America,—its well watered surface, its lofty mountains, its majestic forests, and humid atmosphere,—we shall easily understand how many genera of the ancient continent, dwelling by preference in dry, warm, and sandy situations, for example *Anthia*, *Pimelia*, *Erodius*, and *Brachycerus*, should not occur in the comparatively rich, moist, and shaded soils of the new world. Thus also the carnivorous Coleoptera in America are proportionally of smaller amount than in the old continent, although no quarter of the globe is more productive of large and splendid species among the phytophagous or vegetable-eating tribes of insects. However, the south of China and the Moluccas still maintain a certain superiority in the production of such splendid examples of the lepidopterous order as *Papilio Priamus* and *Bombyx Atlas*, of which the dimensions surpass those of the American species. A fact noted by Latreille is worthy of remembrance, viz. that Europe, Africa, and Western Asia, are extremely unproductive of the genus *Phasma*, or the spectre insect, and that such of the species as do occur are extremely small, while the Moluccas and South America produce many of remarkable size. The atmospheric humidity of the new world, its narrow and elongated form, the nature of its soil, and the vast extent of ocean by which it is environed, are sufficient reasons for the disagreement observable between its productions and those of corresponding latitudes in our own hemisphere. The new world, in fact, bears in many respects the same relation to the old that Britain does to a great portion of Europe.[4]

We have already alluded to the classification of climate given by Fabricius, and to certain circumstances which have been supposed to render the adoption of that classification unadvisable. Latreille has viewed the same subject under a better aspect. He considers the northern extremities of Greenland and of Spitzbergen, under the eighty-first degree of northern latitude, as the points where vegetation terminates. But to obviate all difficulty, and with a view to establish a duodecimal division, which is not only convenient in itself, but also in frequent accordance with the actual observation of geographical groups, he raises this supposed limit of vegetation three degrees higher, that is, to the eighty-fourth degree. If we then divide into successive spaces of twelve degrees, a meridian commencing from the western parts of Spitzbergen, or those nearest to Greenland, we shall have a suite of latitudes corresponding successively to the limits of the countries already alluded to in relation to their zoological productions. He continues these sections duodecimally or by twelve degrees, beyond the equator, and towards the antarctic pole, and stops about the sixtieth degree of southern latitude, under the parallel of Sandwich Land, regarded in that direction as the *ne plus ultra* of geographical discovery.

It appears that a difference in latitude of twelve degrees always produces a very sensible change in the mass of insect species; and that if that space is doubled, the alteration is almost total; as, for example, between the

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[1] See an interesting memoir (which we did not receive till the present pages were in types, and which we consequently have not had time to analyse) entitled "Sur les Lepidoptères de Madagascar, Bourbon, et Maurice," by Dr Boisduval, in the *Nouvelles Annales du Muséum*, t. ii. p. 149.

[2] *Mémoires*, p. 182.

[3] *Introd. to Entomology*, vol. iv. p. 492.

[4] *Mémoires*, p. 184.

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north of Sweden and the north of Spain. An analogous change takes place in relation to the *longitude*, but more slowly, and after a traverse of a greater distance; since the mean temperature, but for causes of a particular and local nature, is not widely different under the same parallel. In proportion as we approach the pole, the extent occupied by particular races embraces a greater number of geographical divisions.

The insects of America, even those of its northern provinces, at least as far as Canada, may be said to differ specifically from those of Europe; but the species of Greenland may rather be regarded as European. The last-named country, so far as the entomological geography of the ancient continent is concerned, is assumed by Latreille as the point of departure for his first meridian. In any view it may be regarded as intermediate between the two hemispheres. The Canaries, the Cape de Verd Islands, and Madeira, are African, judging from their entomological productions. The meridian above named will thus follow a middle line between these islands and the most eastern cape of South America, that of St Roque, near Rio Grande, in Brazil. It will pass by the western isles, or archipelago of the Azores, and by the island of Ascension, and will abut to the westward of Sandwich Land. Its longitude will be thirty-four degrees to the west of the meridian of Paris. According to Latreille's observations on the insects collected by Olivier in Persia, their general relationship to those of the south of Europe and the north of Africa, and the essential differences which they present when compared with the entomological productions of the East Indies, it may be inferred that the most signal changes in the species take place in a southerly direction towards the frontier lines of Persia and Hindustan, and in a northerly direction at a short distance from the eastern slopes of the Uralian Mountains and Lake Aral, a little beyond the sixtieth meridian east of Paris. We may fix this limit approximately at sixty-two degrees, somewhat to the west of the Obi, and of Balk and Candahar, for the sake of affording the means of continuing a duodecimal division; for if we add 62 to 34, the difference between the first meridian and that of Paris, we have the number 96, a quantity susceptible of being divided, without fractions, into eight parts, each equal to the thirtieth portion of the circle. We thus separate the ancient continent into two great bands, of which one is western and the other eastern; and if we assign to the latter the same extent in longitude as the former, that is, ninety-six degrees, it will terminate 158 degrees of eastern longitude from the meridian of Paris. Departing from Kamtchatka, it will pass by the Carolinas, and from thence between New Holland and New Zealand. If augmented by one fourth, or by twenty-four degrees, this eastern band would be bounded by the 182d meridian east of Paris, and passing at a short distance from East Cape, over Behring's Straits, would stretch beyond the Friendly Islands, and form, without any material error in relation to our entomological views, a line of demarcation between Asia and America. The remaining 144 degrees complete the equatorial circle, and compose the extent in longitude of that great zone proper to the insects of America. It may also be divided, and under the same denominations of eastern and western, into two equal portions, each of seventy-two degrees. Thus the entire circle of the equator may be regarded as divisible into four arcs, of which the values are, 72, 72, 96, and 120, or in the proportion of six thirtieths, eight thirtieths, and ten thirtieths. The extent in longitude of the ancient continent will comprise 216 degrees, and that of the new 144.

The lesser zones or climates are denominated *arctic* or *antarctic* by M. Latreille, according to their position on this or the other side of the equator. The climate included between the 84th and 72d degrees of north latitude is named the *polar* climate. Then follow as far as the equator, and always in divisions of twelve degrees, the following climates, viz. the *sub-polar*, the *superior*, the *intermediate*, the *super-tropical*, the *tropical*, and the *equatorial;* and as each hemisphere is partitioned into two great divisions, the climates of each are distinguished by the name of western and eastern. The antarctic climates consist of only three in number, as we know little of what exists amid those chilly regions beyond the 60th degree of south latitude, and thus in that direction both the polar and sub-polar climates may be suppressed. We shall illustrate these views by a few applications to the northern and western kingdoms of Europe, the best known portions of the old world.

The *polar* climate presents us with the insects of the greater part of Greenland, and with those of Iceland and of Spitzbergen. In the *sub-polar* climate we shall find those of Norway, of the north of Sweden, and of Russia in Europe. These two of course contain the insects of the coldest climates of the earth. We may regard as belonging to the *superior* climate the species of Great Britain, of the south of Sweden, of the north of France as far as the inferior course of the Loire, of Prussia, of Germany Proper, and of the south of Russia as far as the Crimea exclusive. The *intermediate* climate, at equal distances from those of the equator and the pole, will comprehend all the species of the south of Europe, and of a portion of the west of Asia. Those of the north of Africa, and as far as the equator, may be classed under the climates called *super-tropical*, *tropical*, and *equatorial.* These western climates may be divided into two equal parts, each consisting of forty-eight degrees, by a meridian which, passing fourteen degrees to the east of Paris, in the vicinity of Vienna, would leave to the east the most southern part of Italy, Turkey in Europe, Egypt, &c. Now it has been already remarked, that many of the insects of the environs of Vienna are also known to occur in the Levant, and that those of the kingdom of Naples, of Egypt, and of the south-east of Europe, appear to differ in many respects from the southern and western species of that division of the globe. We can here, then, effect the formation of sub-climates. If we divide the eastern portion, of which the extent in longitude is 120 degrees, into four equal sections of thirty degrees, by meridians, we shall have sub-climates, of which the boundaries seem very accordant with nature. Thus the first would comprehend Hindustan, Thibet, Little Bucharia, &c. while the second would detach almost all the Philippine Islands, China Proper, and the regions of the north as far as a short way beyond the river Lena. Corea, Japan, and the countries of the Manchous and Tongouses, &c. would form the third subdivision. The fourth would present Kamtchatka, and the other countries which terminate the north-east of Asia. America may likewise be subdivided after a similar manner.

It must, however, be borne in mind that nature, in her distribution of the localities proper to the various races of animals, often swerves from her more regular and accustomed courses, and that the *lines of habitation* form numerous curves and sinuosities, not unfrequently crossed or interrupted by others of a somewhat different nature. We must, therefore, in considering such views as the preceding, make abstraction of particular modifications which alter or derange our theoretical views. Latreille's is but an unfinished sketch of a highly interesting geographical map of Entomology, in which he has endeavoured, as well as he could, to mark out various boundaries, and to divide them according to certain principles in harmony with his actual observations, so far as these have been hitherto carried. The geographical distribution of living beings presents a wide field for speculation, although the modes by which that distribution has been effected will probably in many cases remain for ever concealed from human knowledge. Their gradual extension by natural means, from a single centre of creation, scarcely falls within the sphere of credibility; and thus the creation of various groups of species over different points of the earth's surface, and in accordance with the climate and physical character of different countries,—or the removal and dispersion, by supernatural agency, of the greater proportion of existing species from an original centre,—seem the two points, one or other of which remains to be illustrated by whoever is curious in such bewildering speculations. "A glance at the innumerable and far-spread legions which compose the busy world of insect life renders the subject still more complex and confounding. A discovery ship, under the guidance of brave men, surmounts with difficulty the terrors of the ocean; and, after being months on the trackless main, and some thousand miles from any of the great continents of the earth, she arrives at last and accidentally at some hitherto unknown island of small dimensions, a mere speck in the vast world of waters by which it is surrounded. She probably finds the 'Lord of the Creation' there unknown; but though untrod by human footsteps, how busy is that lonely spot with all the other forms of active life! Even man himself is represented not unaptly by the sagacious and imitative monkeys, which eagerly employ so many vain expedients to drive from their shores what they no doubt regard as merely a stronger species of their race. 'Birds of gayest plume' stand fearlessly before the unsympathizing naturalist; and at every step of the botanical collector the most gorgeous butterflies are wafted from the blossoms of unknown flowers, and beautify the 'living air' with their many splendid hues. Yet how frail are such gaudy wings, and how vainly would they now serve as the means of transport from that solitary spot, where all the present generations have had their birth! In what manner, then, did they become its denizens, or by what means were they transported to a point almost imperceptible in comparison with the immeasurable extent of the circumjacent ocean?"[1]

In the opinion of Humboldt, the causes of the distribution of species, whether in the vegetable or in the animal kingdom, are among the number of mysteries to which natural science cannot attain. This science, or at least that branch of it which takes cognizance of zoological geography, is not occupied in the investigation of the origin of beings, but of the laws in accordance with which they are now distributed over the surface of the earth. It enters into the examination of things as they are, the co-existence of vegetable and animal forms in each latitude, at different heights, and at different degrees of temperature; it studies the relations under which particular organizations are more vigorously developed, multiplied, or modified; but it approaches not problems the solution of which is impossible, since they touch the origin or first existence of the germs of life. "We may add," says that enlightened naturalist, "that the attempts which have been made to explain the distribution of various species over the globe, by the sole influence of climate, date at a period when physical geography was still in its infancy; when, recurring incessantly to pretended contrasts between the two worlds, it was imagined that the whole of Africa and of America resembled the deserts of Egypt and the marshes of Cayenne. At present, when men judge of the state of things, not from one type arbitrarily chosen, but from positive knowledge, it is ascertained that the two continents, in their immense extent, contain countries that are altogether analogous, and that there are regions of America as barren and burning as the interior of Africa."[2] It is indeed true that the migration and distribution of organized bodies can no more be solved as a problem in physical science than the mystery of their original creation; and that "the task of the philosopher is fulfilled when he has indicated the laws in accordance with which nature has distributed the forms of animal and vegetable life."[3]

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In regard to those exquisite tribes which form the more immediate subjects of our present observations, it is known that the increasing intensity and continuance of heat exert a powerful influence on the size, structure, and external adornment of the species. The nearer, in general, that we advance towards equinoctial countries, the more remarkable do we find these creatures, for their largeness of dimension, their singularity of form, and their depth as well as splendour of colour. An accurate knowledge of the distribution of insects is of the highest interest to the geologist and geographer as well as to the entomologist, and may be the means of determining, in doubtful or disputed cases, the natural and what may be called the original limits of countries; as, for example, in the case of islands situated at nearly equal distances between two distant continents. But we cannot here pursue the subject under a more extended form.[4]

Having thus cursorily considered the geographical distribution of insects, we may now devote a brief space to their *local* distribution, or favourite haunts, according to their kind, in any given district. The surface of a country, it has been observed, consists either of mountains, hills, and valleys, or of plains. In either case it may be bare and exposed, or diversified by forests, groves, or copses; and it may also be dry and sandy, or rich and well watered by lakes and rivers. Such parts as are uncovered are greatly varied by the hand both of art and nature, and present heaths or grassy downs, marshes, meadows, or tillage land, each of which is characterized by a difference of soil as well as of vegetable surface. In each the careful entomologist will discover peculiar kinds of insects. "As mountains and hills have usually their own Flora, the insects appropriated to alpine plants can only be met with where their pabulum is found. Here also those northern insects that are impatient of a warm climate will take their station if they migrate to the southward. The predacious beetles likewise sometimes frequent a mountainous district. *Carabus glabratus* was first taken by Professor Hooker on Ingleborough; and probably, if the Welsh and Scotch mountains were duly investigated by an entomologist, many novelties would reward his toils. The valleys and plains, especially those of a sunny exposition, abound in insects. When the heat of the atmosphere indisposes you for motion, you will find it no unprofitable or unpleasant employment, lying on the grass, to search for minute beetles, which you will there find coursing about amongst the tufts and roots of the herbage. Thus you may procure many of the *Pselaphidæ*, which you would not otherwise meet with. Even when the grass is grown up, insects are fond of alighting upon

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[1] *Edinburgh Review*, vol. liii. p. 334. [2] *Personal Narrative*, vol. v. p. 180. [3] *Ibid.* vol. iii. p. 496.

[4] In addition to the works already mentioned, the reader may consult an excellent *Essai sur les Coleoptères de la Guyane Française*, par M. Th. Lacordaire, in the Nouv. Annales du Muséum, t. ii. p. 35; and *Thoughts on the Geographical Distribution of Insects*, in the 6th No. of the *Entomological Magazine*.

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its spikes, and thence drop or run to the ground. Should circumstances ever carry you abroad to the steppes or grassy plains of Tartary, or to Hungary, you will find there two or three species of the singular genus *Lethrus*, which burrows in the soil. Every hole is inhabited by a male and female;—from it they issue to attack the plants or vines; and having cut out the heart of a plant, go backwards like a crab with the prize to their burrow. At the time of pairing, sometimes violent battles, encouraged by the female, take place between the male and a stranger of that sex desirous of admission, which cease only with the death or flight of the stranger. The vicinity and borders of *woods* generally abound in insects of every order, and, if you proceed as hereafter directed, will furnish you with numerous prizes, especially of Lepidoptera. Here alone you can meet with the purple emperor butterfly (*Apatura Iris*); and if properly equipped you may readily secure him."[1]

The aquatic beetles of the genera *Dytiscus*, *Colymbetes*, &c. of course occur in the water. During the evening twilight, however, they frequently leave their moist abodes, and wing their way over the adjacent country. When surprised, after their nocturnal adventures, by the rising sun, they will plunge into whatever water is nearest at hand, and thus rain barrels and washing tubs are sometimes not looked into in vain. Chance often throws into the hands of an entomologist what he has long sedulously sought for without success; and an open window and a lighted candle will sometimes procure what a traverse through the forest, worthy of a North American Indian, would not have obtained. By collecting aquatic plants, duckweed, and "the green mantle of the stagnant pool," and afterwards examining these productions at leisure in a basin of water, many valuable insects of the minuter kinds may be procured. Although the *Gyrinus Viola aquatica* is said to inhabit salt water, that element may be regarded as decidedly adverse to insect life. Brackish water, however, produces several peculiar species, such as *Hydræna marina*, and the large-eyed Cimicidæ. According to Latreille, the genus Pimelia occurs only in soils impregnated with saline particles, or where the genus *Salsola* abounds.

Heaths, though in a general view unproductive of insect life, yield some very beautiful species, such as *Carabus nitens* and *arvensis*, and *Cicindela sylvatica*. In regard to *soils*, such as are light, according to Mr Kirby, are most prolific in insects. Warm sandy banks are frequented by *Cicindela campestris*, *Opatrum sabulosum*, *Helops quisquilius*, &c.; and chalk is extremely attractive. The *Licini*, *Papilio Cleopatra*, several species of *Dasytes*, and *Lamiæ*, seem to delight in the latter substance. Many others are found in chalk-pits, which Mr Kirby does not think should be regarded actually as chalk insects; but rather that they simply fall into the pits, and then become more discernible in consequence of the stronger contrast of colour. By watching in one of these pits during a warm day, vast numbers of insects may be taken. Of all soils *clay* offers the fewest inducements to the entomologist.[2]

Old trees, felled timber, and planks which have lain long upon the ground, should be carefully examined by the collector, as on the under sides of the latter, as well as beneath stones, many species seek repose and shelter. Thorn and other fences, whether dead or living, are very productive; and gates, posts, and wooden rails, ought in nowise to be neglected. Although the *sea* itself, according to the authority last quoted, produces no true insects, yet many and varied tribes are known to haunt its shores. On the sand hills of the Norfolk coast Mr Kirby found *Ægialia globosa* and *Cicindela hybrida*. *Rynchænus horridus* likewise inhabits thistles growing near the sea. Fuci and other marine rejectamenta, which border the margins of friths and estuaries, produce peculiar species of *Cercyon*, some *Aphodii*, and many *Staphylinidæ*. That singular insect *Oxytelus tricornis* has been captured in a situation like that now indicated. The inundations of rivers in spring, summer, and autumn, sweep innumerable insects from their hiding places; and when the waters begin to subside, the examination of the floating grasses, broken twigs, and various debris which line the indented shores, will afford an ample field for the investigations of the entomologist. To him indeed the most barren scene, whether of dreary moor or desolate mountain, can never be devoid of interest,—for the more untrodden the path the stronger and more rational are his hopes of becoming possessed of some of those treasures which are everywhere scattered over the wilderness of nature,—hitherto unperceived perhaps by human eye, but nevertheless performing an essential part in the great and solemn mystery of creation.

The geological relations of insects do not appear to have attracted the notice of naturalists,—we mean their more direct connection with rocks, independent of that intermediate relationship which results from the dependence of particular plants on certain soils, and the known alliance of many tribes of insects with peculiar forms of vegetable life. Mr Wailes always found the larvæ of *Enicoceri* on rough slimy stones, and he found it as great a waste of time to look for them on a smooth limestone, as to turn up a fragment of basaltic rock (whinstone) in search of geodephagous insects. The repugnance of beetles to basalt he had previously noticed. The subjacent rock of the wild district of Teesdale is almost exclusively composed of the basalt of the great whin-sill, the formation of which is regarded as a knotty point by geologists. Of course the loose and superficial stones of the country are its fragments, and among these scarcely a beetle is to be found, except a few which are superlatively common elsewhere, though *inter rariores* in the district referred to. "So far," says Mr Wailes, "as my observations, whether confined to single stones, or extended over a whole district, go, any place having limestone, particularly the magnesian, for its subjacent stratum, will afford abundance of the *Geodephaga*, as well as most other Coleoptera, whilst they will be found very thinly scattered over a basaltic region. It is strange to notice the almost uniform absence of these insects on turning up a whin which has accidentally found its way into a heap of other stones, though every one of the latter may have one or more tenants under it. Must we not look to the comparative dryness of the limestone and humidity of the whin for an explanation? We can readily account for the great predominance of the land *testacea* on a limestone district; but lime does not enter into the composition of beetles."[3]

Insects may also be viewed in relation to their seasons of appearance, or the most appropriate periods for the collection of the different kinds. Such as gather honey and the pollen of plants are among the first to proclaim the approach of spring; and their appearance may be dated from the blossoming of certain trees and flowers of common occurrence. Other plants, likewise accompanied by peculiar insects, blossom later; and thus we may trace a mutual relationship between the two kingdoms throughout the sparkling spring, the leafy summer, and the melancholy autumn,—till relentless winter sets his seal upon insect life, and either renders it entirely torpid, or sheds occasionally a feeble ray on some forlorn company of gnats, whose dances, now no longer "choral," exhibit but a sad representative of that more genial season when the "living air" was filled with their not unjoyful murmurs. With these and a few other exceptions, the earliest insect season commences with the flowering of the sallow (*Salix caprea* of Linnæus, *Saugh* of the Scottish schoolboy), which is accompanied by the golden flowers of the crocus, and the beautiful green of the expanding gooseberries. "Then is your time," says Mr Kirby, "to collect many species of wild bees and *Diptera*, not afterwards to be met with; and various other insects now begin to emerge from the pupa. Another and later season is marked by the general blossoming of the buttercup (*Ranunculus bulbosus*), accompanied by the marsh-marygold (*Caltha palustris*), and ladies' smock (*Cardamine pratensis*), when you may hunt the pastures, meadows, and marshes with success, and take some insects that do not show themselves later. The coprophagous insects are now abundant. Amongst others, *Aphodius testudinarius*, a perfectly *vernal* species, is now only to be taken, and usually flying. A *third* insect season indicated by Flora, and a very prolific one, commences with the blossoming of the hawthorn, when you must desert the meads for the inclosures. At this time all nature begins to put on her gayest attire, and all her insect tribes are now on the alert, and fill the air. They are almost universally attracted by the sweet and lovely blossoms of the plant just named; so that, by examining them, you may entrap some of every order, and many that during the year will appear no more. Even many of the saprophagous insects will sip nectar from the flowers. The umbelliferous plants proclaim the fourth season of insects, particularly the wild carrot and parsnip. You will scarcely ever fail to find, if the weather is genial, *hymenopterous* and *dipterous* insects of various genera, especially such as have a *short* tongue, engaged in collecting the honey from those plants. Here you may take some of the rarer *Chrysidæ*, *Crabronidæ*, *Cercerides*, &c. and occasionally even *Coleoptera*. The last insect season may be dated from the general flowering of the thistle tribe. When these are in blossom is the best time of all to collect the humble-bees (*Bombus*), the leaf-cutter bees (*Megachile*), and many other *Apiariæ*, Lat. which alone, by their long tongues, can imbibe the honey and collect the pollen of these flowers. The male humble-bees frequent them to the last, and often seem as if they were intoxicated with their sweets."[1]

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[1] *Introduc. to Ent.* iv. 499.

[2] *Ibid.* p. 304.

[3] *Entomological Magazine*, iii. 257. For a correct chemical analysis of the constitution of insects see page 63 of this volume of the Encyclopædia.

The preceding chapters contain whatever we have to say of a general nature regarding the CLASS of insects. We shall now proceed to the particular history of those primary divisions called *Orders*, the name and nature of each of which have been already briefly expounded at the commencement of this article.

ORDER I.—COLEOPTERA.[2]

Coleopterous insects have usually four wings, the two superior of which, called elytra, resemble horizontal, somewhat convex scales, which meet in a straight line along their inner margins, where they form what is called the dorsal suture. The inferior wings, which are the true organs of flight, are membranaceous, transparent, transversely folded, and covered and protected by the elytra or wing-cases. They are all masticating insects, provided with mandibles and maxillæ.

Of all the insect tribes these are the most numerous, the best known, and the most generally interesting. Their singular and varied forms, their brilliant colouring, the great size of many species, and that solid consistence which renders their collection and preservation comparatively easy, have long secured for them the devoted attention of the entomologist. Some advantages also result to their study and classification from the clearly defined and articulate forms of their external organs. The name and principal characters of the order were bestowed and defined by Aristotle, and have been adopted by almost all succeeding writers on the subject. Other characters have no doubt been added to his ancient definition of *wings in a sheath*,—such as the transverse folding of these organs, and the straightness of the suture by which the elytra are united; and several exceptions to the supposed universal attributes of the order have been discovered,—such as the female glow-worm, which has neither wings nor sheaths, and the genus *Meloe*, and many *Carabi*, which, though furnished with sheaths or elytra, are entirely destitute of true or membranaceous wings. So also, in the genera *Buprestis*, *Molorchus*, and others, we may discover exceptions to the transverse folding of the last-named organs; and the exact fitting or junction of the elytra, forming the dorsal suture, ceases to hold in the genus *Meloe*,—so that none of these characters can be regarded as universal; but as they are very generally prevalent, and a few exceptions do not invalidate a rule, it is advisable that they should be retained for the purposes of definition.

Coleopterous insects, like others, are composed of three principal portions, head, thorax, and abdomen. The *head* varies greatly both in size and form, according to the different tribes. In the great section of the *Geodephaga*, or ground-beetles, it is usually of a somewhat triangular form; in many of the short elytra'd tribes (*Brachelytra*) it is orbicular; while among the weevils (*Curculionides*) it is prolonged into a pointed rostrum or beak. The hinder part is frequently contracted into a short neck, and is inserted into a cavity of the thorax, in which it moves as in a socket. The head bears two *antennæ*, of which the form and structure differ not only in the different genera, but even in the sexes of the same species. They usually, however, consist of ten or eleven distinct articulations, the latter number being the more frequent. They are inserted in the front of the head, anterior to, and rather beneath, the region of the eyes. Their various forms, as characteristic of particular groups, will be afterwards described. The *eyes* of Coleoptera, in the perfect state, are two in number, and composite. In certain Staphylinidæ, two small yellowish points have been observed, which some naturalists have regarded as analogous to the simple or stemmatic eyes; but the sentiments of Latreille are adverse to that opinion. The actual eyes are either entire, notched, or even occasionally so completely intersected by a little corneous stalk, as to exhibit (as in the genus *Gyrinus*) the appearance of a pair on either side. The *mouth* consists of a *labrum*, two *mandibles*, two *maxillæ*, each furnished with one or two articulated *palpi*, and a

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[1] *Introduc. to Ent.* vol. iv. p. 508.

[2] The derivation or etymology of the different orders has already been given in our introductory observations,—see pages 59 and 60 of this volume. Our present order corresponds to the ELEUTHERATA of Fabricius.

labium composed of two parts, the *mentum* and *ligula*, and accompanied by a pair of palpi. The mandibles are usually of a corneous consistence, but they are membranaceous and of small size, in such as take little apparent nourishment, or feed on the juices of flowers, or on excrementitial or putrescent animal fluids. The maxillæ are of a softer texture than the mandibles. When there are a pair of palpi on each maxilla, the exterior ones never consist of more than four joints; those of the labium have usually three articulations.

The *thorax* of the Coleoptera, like that of other hexapod insects, is likewise divisible into three principal portions, each of which is characterized by a particular degree of development. The *mesothorax* is very narrow, whilst the corselet or *prothorax*, and the *metathorax*, exhibit a considerable bulk. This is an important feature in the structure of the skeleton or tegument of the coleopterous order. The prothorax is always free in its movements, while the two other portions are united together, and nearly immoveable. The component parts of the mesothorax are in fact rudimentary, and those of the *scutellum* are soldered together. But the elements of the latter portion, that is, the *præscutum*, the *scutum*, the *scutellum*, commonly so called, and the *postscutellum*, still exist, and their joinings are quite perceptible in certain genera. The prothorax supports only the first pair of legs, while the mesothorax bears the second pair and the elytra. The second pair of wings and the third pair of legs are attached to the metathorax.

The elytra and wings take their origin from the lateral and superior margins of that portion of the body to which they are attached. The elytra are usually of a very firm or almost crustaceous consistence, opake, and without reticulations. The true wings are large, veined, and concealed beneath the elytra. The latter always exist (with the exception of the females of a few species), but many species are apterous, so far as concerns the existence of the membranaceous wings. In general the elytra equal the body in length, but they are sometimes, as among the Staphylinidæ, much shorter. They are usually free, and extended during the act of flight; but among several carabideous insects they seem united by the dorsal suture, and are consequently incapable of extension. In these instances the true wings are wanting.

The *abdomen* of the Coleoptera is sessile, that is, attached to the metathorax by its largest transverse diameter. Its inferior or ventral part is less extended longitudinally than the superior, and this restriction is chiefly owing to the development of the sternum of the metathorax, which is prolonged backwards, and thus, as it were, usurps the place of the abdomen. This may be very distinctly observed in the genus *Copris*, in which the segments of the abdomen seem crowded together. In some species the first segment appears divided into two parts by the sternum, which projects along their line of union. Inferiorly, the abdomen is always of a firm or horny consistence; but the upper part is generally soft, being covered by the elytra and wings. When these are wanting or abbreviated, the abdomen is equally hard above as below, as in the genus *Meloe*, and the *Staphylinidæ*, or brachelytrous tribes.

The legs vary in their structure and development. The anterior pair, or those of the prothorax, are frequently more strongly formed in the male than in the female; and in the former sex the tarsi are often broader than in the latter. The legs are usually described as composed of five pieces, the *haunch*, the *trochanter*, the *thigh*, the *tibia*, and the *tarsus*. M. Audouin has shown the existence of a sixth portion, moveable, constantly concealed within the interior of the body, and serving to articulate the haunch with the epimera. We have already mentioned it under the name of *trochantin*.

The internal structure of the Coleoptera has recently been illustrated by several ingenious observers, such as Ramdhor, Audouin, and Dufour.

The apparatus for the purposes of nutrition in coleopterous insects may be summed up as follows:[1] 1*st*, Organs of manducation; 2*d*, salivary glands; 3*d*, a digestive tube; 4*th*, biliary vessels. The entire order Coleoptera is composed of *masticating* species, which are consequently provided with instruments of a more or less resistant nature, adapted for seizing, cutting, and triturating the food previous to its being swallowed. For this purpose the mouth is furnished with a pair of corneous mandibles, sometimes simply incisive, sometimes dentated or toothed. Their motion is transverse and horizontal. There is also a pair of maxillæ, usually of a more membranaceous consistence than the mandibles, an upper lip or labrum, an under lip or labium, and from four to six palpi. The salivary glands, which in orthopterous and hemipterous insects present all the characters common to such organs, are rudimentary in size, and few in number, among the coleopterous tribes. They contain a colourless saliva, and their existence hitherto has been ascertained chiefly in genera of the families of *Melasoma*, *Taxicornes*, *Stenelytra*, *Trachelides*, *Rhincophora*, and *Aphidiphaga*. The digestive tube possesses an extent which varies singularly in relation to the habits of life of each particular tribe. In a few it scarcely exceeds the length of the body; while in others, and these are the greater number, it greatly surpasses that extent. The œsophagus is generally short; the crop more or less obvious; the gizzard is in some families garnished interiorly with triturating pieces; the chylific ventricle is of variable size, and either smooth or beset by papillæ; the small intestine likewise varies in length; the large intestine consists most frequently of a dilatable cæcum; the rectum is sometimes greatly elongated in the female sex.

The texture of the digestive tube is musculo-membranous, and is composed of three tunics of varying thickness. The biliary or hepatic vessels are always inserted at the posterior extremity of the chylific ventricle. They are of great extent, extremely slender, singularly folded, and of a cellular-membranous texture. Their number and the mode of their connection vary in the different tribes and genera, but they are always of an equal number, or in pairs. There are never less than a single pair, nor more than three. Sometimes their insertion is limited to the chylific ventricle, in which case they are either free and floating by one extremity, or they form an arch variously twisted, of which the two extremities are implanted on the same circle. Sometimes the insertion is double, and obtains at one end on the chylific ventricle, and at the other on the cæcum. The bile contained in these vessels varies from a deep violet and brown colour, to yellow and white. It is sometimes even diaphanous.

The generative system among the Coleoptera is thus described by M. Dufour. "Les Coléoptères ont, ainsi que les autres insectes, deux sexes séparés, et l'acte de la reproduction est un véritable accouplement. L'organe générateur mâle se compose, 1°. de deux testicules formés, soit par les replis agglomérés d'un seul vaisseau sper-

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[1] See Dufour's *Résumé des Charactères anatomiques propres aux Coléoptères en general et aux Carabiques en particulier.* Ann. des Sciences Nat. t. viii. p. 36.

Coleoptera.

matique, soit par un ou plusieurs sachets, soit enfin par des utricules dont le nombre, la configuration, et la grandeur varient suivant les familles ; 2°. de deux canaux déférens variables pour leur longeur, quelquefois reployés en épidedyme ; 3°. de vésicules séminales plus ou moins nombreuses, et de formes diverses suivant les genrcs de Coléoptères ; 4°. d'un conduit éjaculateur tantôt fort long, tantôt très-court ; 5°. d'une verge retractile renfermée dans une armure copulatrice dont la conformation se modifie à l'infini. On distingue dans l'organe générateur femelle de tous les Coléoptères, 6°. deux ovaires dont chacun se compose d'un calice plus ou moins marqué, et d'un nombre variable suivant les genres, de gaines ovigères uniloculaires ou multiloculaires, terminées le plus souvent par une pièce charnue où se fixe un ligament suspenseur ; 7°. un glande sébacée d'une structure diversement compliquée, insérée à l'origine de l'oviducte, et destinée à furnir une humeur propre à lubrefier ou à enduire les œufs à l'époque de la ponte ; 8°. un oviducte plus ou moins long qui se continue en un vagin ; 9°. enfin, dans quelques cas rares un appareil sécréteur particulier propre à former une enveloppe commune ou une coque aux œufs."[1]

Besides the ordinary secreting organs, certain coleopterous species are provided with a kind of excrementary secreting apparatus, which is binary, and common to both sexes. Its function is the formation of an acrid humour, liquid or gaseous, which the insect expels as a means of defence when menaced or attacked.

The respiratory organs of the Coleoptera consist in stigmata placed along the lateral portions of the body, and of tracheæ, sometimes tubular, sometimes utricular, which disseminate the air through all parts of the system.

The nervous system is composed of a brain or upper ganglion,—of ganglia placed in the median line, variable in their number, and communicating with each other and with the brain by means of a double cord,—and of nerves, properly so called, which emanate from the ganglia.

The abdominal cavity of these insects always encloses a splanchnic adipose tissue, of which the abundance and colour vary according to the genera, and which appears to be connected with the purposes of nutrition.[2]

In addition to the usual differences, the sexes frequently present external distinctive characters in the antennæ and other parts. The male is supposed to perish soon after the sexual union, and the female does not long survive the deposition of her eggs. These eggs, which of course vary in size, form, colour, and consistence, are deposited in various localities, and among very different substances, in accordance with the instincts and economy of the species, and the habits of the larvæ about to be produced. These larvæ are also very dissimilar to each other in this varied order; but they may be generally described as soft bodied, with the exception of the head and the upper portion of the three first segments of the body, which are of a firmer or more scaly consistence. They are furnished with six feet; and the eyes, which in the perfect state are composite, are in this early condition small granuliform bodies, sometimes amounting to six on each side. The parts of the mouth bear a relation, both to their immediate mode of life, and their future development in the perfect insect. The mandibles are very strong and corneous in such species as feed on ligneous substances; they are coriaceous in such as feed on leaves, and almost membranaceous in those which prefer carcasses, or other matters in a state of putrescence. The antennæ of these larvæ are usually very short, cylindrical or conical, and composed of a small number of articulations.

Coleopterous insects enjoy a considerable length of life, at least in the larva state. The period of endurance, however, of that early condition, is extremely various in the different genera of this most numerous order. Indeed, even among individuals of the same species, the continuance of the different stages of growth varies in accordance with the temperature of particular seasons, or the more or less abundant supply of food. Many species pass the winter in a listless state, abstaining almost entirely from eating, and consequently, even after the lapse of several months, present scarcely any apparent increase of their dimensions. No sooner, however, are they awakened from their temporary trance by the enlivening beams of the returning sun, than they greedily attack their favourite food, and their growth is almost instantaneous. It has been remarked that the larvæ which feed on leaves, such as those of *Crioceris*, *Altica*, and *Chrysomela*, remain but a brief period in the larva state; while the subterranean and root-devouring species, on the contrary, not unfrequently continue for two or three years in their dark abodes. Attentive observation has also ascertained that those Coleoptera which pass the winter in the egg state are the shortest lived in the form of larvæ;—they are hatched, nourished, developed, reproduce, and perish, all in the course of the summer first ensuing,—while such as pass the winter in the larva state, or that of nymph, are the longest lived in both of those conditions. It is chiefly in the form of larva that the Coleoptera produce such injury to agriculture, and other branches of rural industry. The ravages of species belonging to the genera *Bruchus*, *Curculio*, *Calandra*, *Melolontha*, *Crioceris*, *Altica*, *Anthrenus*, *Dermestes*, and numerous others, are unfortunately better known than any counteracting remedies of easy application.

The larvæ of the coleopterous tribes usually change their skins three times, and many of those which live in the earth construct a kind of cocoon, in which they undergo their transformations. These are of the kind formerly mentioned under the name of *complete* metamorphoses.

Linnæus, Geoffroy, Fabricius, Olivier, Latreille, and others, have established many divisions, more or less natural, in the coleopterous order. The number of the articulations of the tarsi varies from three to five, and their amount in each limb has been assumed as the basis of the great sectional divisions of the coleopterous order, so generally adopted by the continental naturalists. As these divisions pervade all foreign works of importance on the Coleoptera, we shall here explain their nature. Geoffroy having observed that all the species of a genus or of a family were characterized by the same number of articulations of the tarsi, and that the differences presented by these parts always bore a relation to other differences in the general organization, he conceived the idea of grounding his primary divisions on their particular structure.

Many extensive families of coleopterous insects are distinguished by *five* articulations to the tarsi; that is, by five joints on each foot. (See Plate CCXX. fig. 2 *e*.) All of these fall under the first general section called *Pentamera*, from πεντα, *five*, and μερος, *part* or *article*. Another extensive division is characterized by *five* articulations to the tarsi of the two anterior pair of feet, while the posterior or third pair possesses only *four* articulations. All the species so formed belong to the section *Heteromera*, so called from ἑτερος, *different*, the tarsi being dissimilar to each other. Numerous Coleoptera exhibit the tarsi composed throughout of four articulations. These are ranged under the general section *Tetramera*, from τετρα, *four*. Lastly, many species have no more than three, and some no more than two joints, to the tarsi, and these belong respectively to the sections *Trimera* and *Dimera*. It has even been supposed that an insect exists, the tarsi of which are furnished with only a single joint; and for its reception the section *Monomera* (from μονος, *alone*) has been established. Later and more considerate observation, however, has led to the belief that both of the last-named sections are resolvable among the trimerous species, and that the supposed absence of the second and third joints arises from their extreme minuteness.

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[1] *Ann. des Sciences Nat.* t. viii. p. 38.

[2] *Ibid.* p. 40.

"Nihil notatu dignius videtur," observes Mr Fischer, "constanti tarsorum insectorum imprimis coleopterorum formatione, quæ, quidquid etiam naturæ scrutatores, quidam contra eam in medium protulerint, methodum ordines insectorum in sectiones vel series minores dirimendi offert tutissimam."[1] The extreme simplicity, and consequent ease of application, of the sectional rules deduced from the structure of the tarsi, has probably induced the continental naturalists to adopt them more readily than they would have done had they foreseen the occasional contradictions to which they lead. The fact cannot be disguised that the system is in many instances artificial,—for several insects differ in the number of their tarsi, which are yet nearly allied by their general structure and attributes,—while it would be easy to show that the mere agreement in the number of those parts by no means carries along with it a corresponding relationship in the form of the other more important organs.[2] The truth is, that the articulations of the tarsi differ in some instances even in the sexes of the same species, as may be seen in *Cryptophagus fumatus* and *C. pallens*; and the consequence, as Mr Macleay has pointed out, of forming the primary divisions in accordance with their amount, has been, that many genera are separated, and thrown to a great distance from the place which nature has assigned them.[3]

While, therefore, the British naturalists have availed themselves of whatever aid these sectional divisions have legitimately afforded, they do not trammel themselves by a uniform adherence to the system, independent of its accordance with nature.[4]

We have already endeavoured, in the preceding introduction, to illustrate the geographical distribution of insects in general. We shall here add a few observations more especially applicable to the coleopterous tribes.

The coleopterous insects of Europe in general, according to M. Latreille, bear a strong affinity to those of Western Asia and Northern Africa. These traits of resemblance become more obvious, when, the qualities of the soil and the temperature being analogous, we approach towards the northern tropic. It is under the forty-fourth degree of north latitude that we begin to perceive certain species of carnivorous Coleoptera, of the Lamellicornes, of the heteromerous section, and of the Curculionides, characteristic of the warmer regions of the earth. There also may be observed species of a larger size, and of an aspect more imposing, than characterize their congeners of the north. The dominion of the *Carabi*, properly so called, so notable over all the northern and temperate countries of Europe, and in the more western regions of Asia, ceases towards the thirty-fifth degree of north latitude. These predaceous insects are succeeded by the genera *Anthia* and *Graphipterus*. Viewed in relation to entomological characters, Europe may be said to extend further eastward than it does in accordance with our actual political divisions, as the insects of the Levant, and even of Persia, exhibit a very European aspect. Austria and Hungary, from their central situation and other local circumstances, are numerically richer in species than the western countries of Europe. These latter, however, possess, in consequence probably of their littoral position, and the influence of the oceanic waters, several peculiar species, which, though unknown in the East, nevertheless extend their localities in a lengthened line from north to south. However gorgeous may be the productions of tropical regions, the European continent presents to the entomologist a rich and varied assemblage both of carnivorous and herbivorous Coleoptera. Many of these it possesses in common with other countries, while of some it has to boast a more exclusive possession. The great tribe of the Carnivora, and especially the Carabi or larger predaceous beetles—the *Staphylinidæ* or brachelytrous kinds—the *Clavicornes*—the genera *Aphodius*, *Meloe*, *Callidium*, *Leptura*, *Chrysomela*,[5] *Lixus*, &c.—are there proportionally more numerous than in any other quarter of the world. Latreille has observed that the herbivorous Coleoptera seem to prevail in South America. Many species of the northern countries of the new world greatly resemble those of the northern and temperate parts of Europe, while others are identical. Of these some may be regarded as naturally distributed alike over Scandinavia, Greenland, the adjacent islands, and North America,—while the greater proportion, which are xylophagous or timber-eating insects, have very probably been transported by artificial means, that is, in cargoes of wood, and in the timbers of our vessels. Notwithstanding many examples which might be adduced to illustrate a certain agreement which exists between the species of Europe and North America, the more general as well as precise truth is, that the entomology of North America is connected by a stronger affinity with that of the southern division of the new world than with that of our own continent and islands. We cannot, for instance, exhibit a single example of that division of *Cetonia* of which the thorax presents a posterior lobe, nor of *Galerita*, *Tetraonyx*, or *Parandra*, genera which are distributed throughout the whole of America. One strong feature of conformity has indeed been observed, that North America and Europe both possess many carnivorous Coleoptera entirely unknown in the equatorial regions either of the old world or the new.[6]

The coleopterous order is extremely numerous in species. Comte Dejean's collection, probably the most extensive hitherto made, is said to contain above twenty thousand different kinds; and Mr Stephens' *Nomenclature of British Insects* (second edition) presents us with the names of 3614 indigenous Coleoptera.

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[1] *Genera Insectorum*, Præf. p. 5.

[2] "Ce n'est pas assez," says Clairville, "pour pallier les frequentes anomalies qui se rencontrent, de dire que tel insecte a cinq articles aux tarses quoiqu'on n'en découvre que quatre. Il devroit en effet en avoir cinq d'après la règle qu'on a établie. Cependant ces explications, toutes ingenieuses qu'elles sont, ne peuvent me convaincre, et je ne puis me détérminer a supposé plus d'articles aux tarses qu'on ne peut réellement en decouvrir, en y mettant toute l'attention possible. Le nombre des articles doit être clair, positif, et uniforme, sans quoi le charactère est vacillant. Au reste, je ne disconviendrai pas que sans être rigoureusement propres à diviser les ordres, ils ne puissent tres-bien servir pour un tableau dans lequel les genres seroient ordonnés selon le nombre des articles des tarses." (*Entomologie Helvétique*, p. 30.)

[3] *Horæ Entomologicæ*, part i. p. 6.

[4] *Entomologia Edinensis*, Introduc. p. 23.

[5] M. Lacordaire, however, has recently shown that the *Chrysomelidæ* are very numerous in the tropical regions of South America. See *Nouvelles Annales des Mus.* t. ii. p. 94.

[6] *Introduction à la Géographie générale des Arachnides et des Inscctes, ou des climats propres à ces Animaux.* Par Latreille.

In relation to the economical uses of the order, we may observe that coleopterous insects are scarcely if at all applied in the arts. Those employed in medicine are chiefly the *Cantharis vesicatoria*, commonly called the Spanish Fly, and the *Mylabris Cichorii*, which in China and the Levant is likewise used as a blistering application. The Romans are supposed to have made use of certain coleopterous larvæ for dietetical purposes; and some of the South American tribes are known to devour with delight the fattened larvæ of the *Curculio palmarum*. We shall conclude these introductory observations by a few remarks

On the collecting and preserving of Coleopterous Insects.

This is a very simple matter to those who are zealous in the cause. By far the best method is for the collector to provide himself with a few stout phials half filled with whisky, or any other ardent spirit which he may happen to prefer. When the insects are caught, which they can only be in any considerable number or variety by a sedulous search under stones, and in the other localities afterwards indicated in our notices of the different genera, they may be popped into the phial, where in most instances they die almost instantaneously. This is not only the most humane process, but it is also the best mode of preserving their more delicate portions uninjured. It likewise puts an end to all contention among themselves, which is by no means the effect of the ordinary method of collecting in small boxes,—for in the latter case the larger and more voracious invariably devour the smaller or least assuming; and thus many captures, regarded with pleasure in the morning, are found to have disappeared in the afternoon. If time and opportunity are wanting for the immediate purpose of *setting* the specimens, that is, placing them in their most appropriate positions, they may be allowed to remain in the phials for days or weeks without being injured, although in that case greater care is afterwards necessary, especially with the smaller specimens, in consequence of a certain softness in the articulations, induced by maceration in the spirits. When an entomologist (in search of Coleoptera) is employed in what we may call the *home circuit*, he requires during his excursions nothing more than a couple of glass phials, as we must suppose him possessed of all other appliances within his dwelling. But during a more distant and prolonged journey, he must provide himself with a few small boxes made either of wood or tin (the last is lighter and thinner, and therefore more commodious), lined with cork at top and bottom, and deep enough to contain an upper and an under range of pins. In these the insects caught during the day may be transfixed in the course of the evening, so that the phials may be left empty for the captures of the ensuing morn. Notes ought to be taken of the places of capture, and the insects should be so arranged in the boxes that, by means of numerals or other marks, any individual may be afterwards recognised in relation to its own particular locality.

The *setting* of an insect consists merely in placing its limbs and antennæ in a natural position, and fixing them in the same for a time by means of pins, on a small board on which there is a layer of cork. (See Plate CCXX. figs. 10 and 12.) They stiffen in a few days, and may then be transferred to their proper places in the cabinet. If not set when either moist or recent, they may be softened by being placed for a night in any small vessel containing a layer of wet sand, and covered with a damp cloth to prevent evaporation. The same process, continued for a somewhat longer time, is equally efficient in regard to foreign species. Each specimen, if not stuck, should, previous to setting, be transfixed by passing a pin through the elytra and abdomen, at right angles with the plane of its position,—enough of the pin being made to project beyond the feet as will suffice to fix its point firmly in the cork.

When mould appears upon coleopterous specimens, they ought to be exposed for some hours at the distance of two or three feet from a brisk fire, and then delicately brushed with a hair pencil. When mites or acari make their appearance among them, they ought either to be exposed for a few minutes to a high temperature, which kills the living parasites without injuring the dead insects, or each specimen ought to be carefully washed by means of a hair pencil dipped in spirit of turpentine. A piece of sponge constantly saturated with that fluid, or a supply of camphor, should be kept in each drawer. With a view to maintain a collection in good order, it is very advisable that all specimens obtained from correspondents by purchase or exchange should, previous to their being placed in the cabinet, be submitted to the ordeal of a bath either in spirit of turpentine or camphorated spirit of wine. If mites or acari are once introduced into a cabinet of considerable extent, their eradication is extremely troublesome. As many collectors are careless of their duplicate specimens, and as it is of course with these that they supply their friends, much injury is frequently inflicted by the introduction even of a single insect in bad condition into a cabinet previously in a proper state.[1] We must now proceed to a more detailed exposition of the coleopterous tribes. They are grouped together under four great sections, according to the number of joints in the tarsi.

PENTAMERA.

All the Tarsi composed of Five Joints.[2]

FAMILY I.—CARNIVORA, Cuv. ADEPHAGA,[3] Clairv.

The first primary division of the coleopterous order contains a numerous and varied assemblage, all of which, however, agree in being, as the name imports, of a voracious disposition. Each maxilla is furnished with two palpi, so that there are *six* in all, including those of the labium.

In the larva state, these insects are elongated, cylindrical, composed of twelve rings or segments, exclusive of the head, which is large, of a scaly texture, and provided with two strong mandibles curved at their extremities. The mouth is also furnished with a pair of maxillæ divided into two branches, one of which is formed by a palpus. The ligula bears two palpi, which are shorter than those of the maxillæ. The head is moreover provided with a pair of short conical antennæ, and six small simple

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[1] *Entomologia Edinensis*, Introduction, p. 57.

[2] We have already stated our opinion of the artificial combinations which occasionally result from the use of this principle of sectional division, and in our *Entomologia Edinensis* we have, with our coadjutor, the Rev. James Duncan, followed another mode of arrangement. But in presenting a general view of the subject, and one in which numerous foreign genera are included, we think that greater clearness will result from an adherence to the system of the continental entomologists. We therefore now follow M. Latreille.

[3] So named from αδηφαγος, voracious.

Coleoptera Pentamera.

eyes on each side.[1] The first segment of the body is covered by a squamous shield,—the others are soft. The first three segments are each furnished with a pair of legs, of which the extremity is curved forwards.

Of course many modifications occur in the form and aspect of adephagous larvæ. For example, those of the Cicindelæ have the upper portion of the head hollowed out in the centre, while the inferior portion is bulged. Two of the eyes on each side are much larger than the others, and the shield of the first segment of the body is also large, and of a semicircular shape. The eighth segment bears two small hooked processes in its upper surface. Among the generality, however, of these larvæ, the head is weaker and more regular, and the eyes are of equal size. The shield is square, and does not project over the sides; the eighth segment wants the processes; but the terminal segment is furnished with two conical appendages, besides a membranous tube formed by the prolongation of the anal portion of the body. These appendages are toothed and horny in the larvæ of *Calasoma* and *Carabus*. In *Harpalus* and *Licinus* they are more elongated, fleshy, and articulated. In these and other genera, the form of the mandibles in the larvæ approaches that of the same species in the perfect state.

The adephagous Coleoptera have always a first stomach, which is short and fleshy,—a second, which is more elongated, and shaggy on the surface, by reason of the numerous small vessels with which it is furnished,—and a short and slender intestine. The hepatic vessels, four in number, are inserted near the pylorus. These insects may be regarded as terrestrial (*Geodephaga*) and aquatic (*Hygrodephaga*), according to their mode of life.

The genera of the former subdivision of the order dwell and take their food upon the surface of the earth. They are hence known under the name of ground-beetles. The feet of these *terrestrial* species are formed for tolerably rapid motion, and the two posterior pair are inserted at equal distances. The mandibles are obvious and discovered, the terminal portion of the maxillæ is straight inferiorly, and curved only at its extremity. The body is generally oblong,—the eyes projecting. The tracheæ are tubular or elastic, and the intestine is terminated by an expanded cloaca, provided with two small sacs which produce an acrid humour.[2]

Tribe 1st, Cicindeletæ, Lat.

This tribe corresponds to the genus Cicindela of Linnæus. Its genera are distinguished by a hook or nail, which is articulated by its base to the tip of the maxillæ. All the species have a strong head, with large eyes, projecting toothed mandibles, and a short ligula concealed behind the mentum. The labial palpi are composed of four distinct articulations, and, in common with the maxillary palpi, are generally shaggy, or somewhat clothed. The precedence is usually assigned to these insects in our systematic arrangements, from motives probably similar to those which have induced ornithologists to place the accipitrine order at the head of the class of birds. The greater proportion of the species are exotic.

Genus Manticora,[3] Fab. Tarsi alike in both sexes, and composed of cylindrical articulations. Mandibles large and arched. Head very large. Eyes small, and not greatly projecting. Back of the thorax forming a kind of semicircular lobe, prolonged as far as the posterior margin. Abdomen pediculated, almost entirely enveloped by the elytra, which are nearly heart-shaped, soldered, and laterally carinated.

M. *maxillosa*, Fab. (Plate CCXXI. fig. 1.) Entirely black, and covered with scattered hairs. The mandibles have four interior teeth, of which the third is the least. The antennæ are slender and filiform, their third articulation angular and elongated. The thorax appears as if divided into two by a transverse groove near the anterior margin, which is prolonged laterally, and beneath, as far as the origin of the fore-legs. There is no scutellum visible. The legs are large, and covered with stiff hairs.

This formidable-looking insect, which measures more than an inch and a half in length, presents the aspect of a large spider. It inhabits sandy soil in the southern parts of Africa, and is the only known species of the genus, unless the *M. pallida* of Fab. referred by Mr Macleay to his genus *Platychiles*,[4] is still to be regarded as a Manticora.

Genus Megacephala,[5] Lat. The first three joints of the anterior tarsi of the males dilated, short, almost in the form of a reversed triangle, more strongly ciliated inwards than externally. Labial palpi longer than the maxillary, —their first articulation elongated, projecting beyond the mentum, the second very short, the third very long and cylindrical, the last securiform. Labrum short and transversal, leaving the mandibles exposed.

This genus was constituted by Latreille by the removal of certain species of *Cicindelæ* of Fabricius. It occurs both in Africa and America. Those from the former country are apterous, from the latter winged. We know little more of their habits than that they are extremely active. We are acquainted with fifteen species, none of which occur in Europe.

M. *megalocephala*, Lat. Of a bronzed black colour; the mouth, antennæ, and feet pale yellow. Elytra with rows of hollow spots. From Senegal.

In the genus *Oxycheila* of Dejean (*Species Gén*. t. i. p. 15) the labrum is very large, with a projecting point, and covers the mandibles. It is formed from the *Cicindela tristis* of Fab., and is named from ὀξῦς, *pointed*, and χειλος, *lip*.

Genus Cicindela, Lin. (Plate CCXXI. figs. 2 and 5.) The first three joints of the anterior tarsi of the males dilated, elongated, nearly cylindrical, and more strongly ciliated inwards than externally. Labial palpi not surpassing the length of the maxillary; their first two joints very short, the first not passing beyond the extremity of the mentum, the third cylindrical, the last slightly enlarged at its extremity.

The name by which our present genus is distinguished is used by Pliny as synonymous with *Lampyris*, to designate a kind of luminous insect, a frequenter of corn fields.[6] It likewise appears to have been applied by ancient writers to various destructive insects which it would now be difficult to identify, although they are no doubt known to naturalists. In modern times it was originally bestowed by M. Geoffroy on the species at present classed under the genera *Malachius* and *Telephorus*, and was afterwards transferred by Linnæus to the insects above defined, as well as to other species not now included in *Cicindela*.

Their larvæ inhabit holes in the earth, the entrance to which, while the occupant lies in ambuscade, is closed by the upper portion of its head. They are exceedingly voracious, and seize with their maxillæ whatever insect prey approaches within their tyrannous grasp. The bodies of these larvæ are long, cylindrical, whitish, and furnished with six scaly feet. When approached by human footsteps, or otherwise threatened by danger, they rapidly descend into their subterranean retreats. When two of these larvæ happen to form their domiciles in the immediate neighbourhood of each other, the stronger devours the weaker, with a view to obviate any interference with his own pursuits. They seal up the entrance to their dwellings when about to change their skins or assume the state of nymph.

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[1] So says Latreille. Some authors state the number of these eyes as only three on each side.

[2] *Règne Animal*, tom. iv. p. 358. An abstract of the anatomical characters of the insects of this division, by M. Dufour, will be found in the *Annales des Sciences Nat.* tom. viii. p. 36.

[3] Μαντιχωρα is the name of a fabulous animal mentioned by Aristotle, Ælian, and Pliny.

[4] *Annulosa Javanica*, vol. i. p. 9.

[5] From μεγας, *great*, and κεφαλη, *head*.

[6] Plin. viii. c. 26.

The perfect insects are extremely beautiful, of light and active forms, exceedingly swift in their motions, and adorned by brilliant metallic colours. The prevailing hues are different shades of golden green, spotted with white or pale yellow. They frequent dry and sandy soils, where they seem to enjoy the prevalence of bright sunshine. The species are extensively distributed over all the regions of the earth. Their organs of locomotion, and those more immediately subservient to the preservation and nutrition of the individual, are very fully developed, and present in the most perfect form all the attributes which distinguish the entomophagous or insect-eating Coleoptera. They were named by Linnæus the tigers of the insect tribes. "Though decorated with brilliant colours, they prey upon the whole insect race; their formidable jaws, which cross each other, are armed with fearful fangs, showing to what use they are applicable; and the extreme velocity with which they can either run or fly renders hopeless any attempt to elude their pursuit. Their larvæ are also equally tremendous with the imago, having six eyes, three on each side, seated on a lateral elevation of the head, which look like those of spiders; and, besides their threatening jaws, armed with a strong internal tooth, being furnished with a pair of spines resembling somewhat the sting of a scorpion, which stand erect upon the back of the abdomen, and give them a most ferocious aspect."[1] It is this last apparatus which, according to Clairville, serves the purpose of an anchor in retaining these larvæ at any desired height in their sandy cells.

Dejean's catalogue (2d edition) contains 201 species of the genus Cicindela as now restricted.

C. *campestris.* Green, with five whitish spots on the margin of each elytron, and another in the centre. The spots on the elytra vary in shape and disposition, and some of them are occasionally obliterated. The female has two fuscous spots towards the base of the elytra, and is distinguished, in addition to the more slender tarsi, by having the abdomen divided into six segments; that of the opposite sex consisting of seven, with the penultimate one more or less emarginate. This sexual distinction, first observed by Gyllenhal, exists in most genera of the tribe.

This beautiful insect frequents dry sandy places exposed to the sun, most commonly in the neighbourhood of heaths, and is distributed more or less abundantly over all parts of Britain. We have traced it through most of the Highlands of Scotland, as far as the south of Sutherland, and we doubt not that it extends to the most northern extremity of the island. It is an inhabitant of most European countries, ranging from the shores of the Mediterranean to Siberia. This is the most abundant of the British species, and the only one yet found in Scotland. The supposed species *C. Maroccana*, Fab. which occurs in Spain and along the coast of Barbary, is now regarded as one of its varieties.

Besides the preceding, five or six other species are described as British. *C. germanica*, an English insect, common in France and Germany, differs in its habits from the rest of the genus. When we attempt to seize it, it does not fly off like the others (although it is winged), but endeavours to escape by running rapidly among the herbage by which it may be surrounded.

The genus *Euprosopus* of Latreille and Dejean, of which the tarsi are equally ciliated on both sides, was established on *Cicindela quadrinotata* of Fab. The species are said to dwell on trees. In the genus *Therates*, Lat. the tarsi are nearly alike in both sexes. The internal maxillary palpi are very small, indistinct, and apparently uniarticulate. The species are confined to the eastern parts of Asia, such as Java, the isles of Sunda, and those to the north of New Holland. *C. labiata* of Fab. belongs to the genus last named, which is synonymous with *Eurychiles* of Bonelli.[2] *C. Aptera* of Olivier forms the genus *Tricondyla* of Latreille.

GENUS COLLIURIS, Lat. Fourth articulation of all the tarsi prolonged obliquely inwards in both sexes. Body narrow and elongated. Thorax almost cylindrical, narrowed anteriorly. Antennæ short, thickening more or less towards the extremity. Last article of the labial palpi dilated.

The title of *Colliuris* was bestowed originally by Degeer, upon an insect belonging to the genus *Casnonia* of Lat. It was established according to its present character by Fabricius under the name of *Collyris*, which has been altered as above by the majority of authors. These insects appear to be all provided with wings. All the species yet met with have been found in the most southern countries of Asia, and in the islands lying north of New Holland.

C. *longicollis*, Dej. Blue, sometimes tinged with violet. Thighs and hind tarsi ferruginous red. Elytra deeply punctured. This species was taken in Java by the excellent Westermann of Copenhagen, who presented it to Comte Dejean as the true *C. longicollis* of Lat. The insect so named by Latreille (*Gen. Crust. et Insect.* i. p. 174) is the *C. emarginata* of the *Species Général*, t. i. p. 165.

We shall conclude our sketch of this tribe by presenting a *synoptical view* of its most recent constitution, according to the system of Dejean.

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[1] *Introd. to Entomology*, vol. ii. p. 263.

[2] *Mem. della R. Acad. di Torino*, xxiii. part 1st, p. 248.

CICINDELETÆ.

- Mentum with a tooth in the centre of its notch. The three first joints of the anterior tarsi
  - not dilated in the males............ 1. *Manticora.*
  - dilated in the males. Third joint of the anterior tarsi of the males
    - not elongate. Penultimate joint of the labial palpi
      - not inflated. Labial palpi
        - elongate, at least as long as the maxillary pair, the last joint securiform. Upper lip
          - transverse or slightly notched. First joint of the labial palpi
            - not extending beyond the notch of the mentum.... 2. *Platychile.*
            - extending beyond the notch of the mentum......... 3. *Megacephala.*
          - covering the mandibles,
            - triangular............ 4. *Oxycheila.*
            - semi-oval............ 5. *Iresia.*
        - slightly elongate, not exceeding the maxillary pair; last joint not securiform............ 6. *Cicindela.*
      - inflated and larger than the last. The three first joints of the anterior tarsi of the males
        - elongate and nearly cylindrical............ 7. *Dromica.*
        - somewhat elongate and flat............ 8. *Eprosopus.*
    - produced obliquely on the inner side............ 9. *Ctenostoma.*
- Mentum without a tooth in the centre of its notch.
  - Third and fourth joints of the tarsi much shorter than the first............10. *Therates.*
  - Joints of the tarsi nearly equal.
    - Three first joints of the anterior tarsi of the males dilated; the third produced obliquely on the inner side............11. *Tricondyla.*
    - Fourth joint of all the tarsi produced obliquely on the inner side in both sexes............12. *Colliuris.*

TRIBE 2D, CARABICI, Lat.

This important tribe corresponds to the old and unrestricted genus *Carabus* of Linnæus. The maxillæ are terminated simply by a point or hook, which is not articulated, as in the preceding genera. The head does not exceed the breadth of the thorax, and is more frequently somewhat narrower. The mandibles, with few exceptions, are but sparingly toothed. The ligula is usually projecting, and the labial palpi exhibit only three free articulations.[1] Many species are apterous, that is, have no membranous wings beneath the elytra. Their odour is often fetid, and their bodies exude an acrid fluid. The habits and economy both of the larvæ and perfect insects are exceedingly various. Some conceal themselves under the earth, others beneath stones, or the bark of trees. They are active in their movements, and are very generally distributed, being, however, more characteristic of temperate than equatorial regions. M. Geoffroy bestowed the generic name of *Buprestis* upon carabideous insects, on account of the injury which he supposed them capable of inflicting on cattle; and it is possible that the caustic humour with which many of them are imbued might be productive of bad effects in the event of their being swallowed along with better and more accustomed pasture. To whatever species this evil tendency was attributed, the ancients appear to have regarded its other characters with admiration, for the physicians of olden times held it as equal in virtue to Cantharides. Linnæus, however, transferred the name of Buprestis to the genus *Cucujus* of Geoffroy, although none of the latter genus in any way corresponded to the Βουπρηστις of the Greeks. The change proposed by the great reformer has been universally adopted, and the word Carabus is now most familiar to the ear of the entomologist.

As the larvæ of the Carabici dwell in subterranean retreats, a knowledge of their habits and history is difficult to acquire. The body is of an elongated form; the legs are six in number, and of a scaly texture; and the maxillæ are strong and pincer-like. With these they seize upon the larvæ of other insects, which constitute their favourite food. They are extremely voracious.

In relation to the economical purposes of the human race, the tribes now under consideration are of no great utility. It is mentioned, however, by the younger Geoffroy, that while he was collecting insects on the coast of Senegal, a negro brought him a jar containing many thousand specimens of a small carabideous species, which had evidently been previously collected by design. On inquiry he found that they were used for making *soap*, some of which, of a black colour, he afterwards examined, and found it to possess all the qualities of the European article. Olivier asks whether we could not extract from our indigenous species an alkaline matter subservient to the same ends?[2]

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[1] In the genus Cicindela the radical joint is free, on which account the palpi are said to consist of four articulations; but among the Carabici it is adherent, and, forming only a support to the others, is not itself regarded as an articulation.

[2] *Hist. des Insectes*, vol. iii. No. 35, p. 11.

Coleoptera Pentamera.

A.

Exterior palpi not subulate or awl-shaped at their extremity; the last articulation not united with the preceding so as to form an oval body with a sharp point, or a conical one with a slender and acicular termination.

*

Two anterior tibiæ with a deep emargination in the internal side separating the two spines, which are usually placed near each other, at the extremity of that side.

SECTION 1ST, TRUNCATIPENNES.

This group derives its name from the aspect of the elytra, which appear as if cut at their extremity, or more or less truncated. This is the prevailing character, although *Odocantha dorsalis* and Dejean's new genus *Stenodactyla* present a rounded termination; but in seeking a natural system, it is the totality of organization or assemblage of characters by which we must be guided, and not by a single feature, although by its wide prevalence that feature may have been assumed, as in the present instance, for a general basis in the naming of the entire group. The two following genera present rather a sinuation than a truncation of the extremities of the elytra.

GENUS ANTHIA,[1] Weber, Fab. Terminal joint of the palpi almost cylindrical, or slightly enlarged at the extremity. Antennæ filiform. Labrum rounded, advanced, and almost entirely covering the mandibles. No tooth in the centre of the emargination of the mentum. Anterior tarsi slightly dilated in the males. Body thick, more or less elongated. Thorax more or less heart-shaped. Elytra convex, not much truncated, or nearly round at their extremity.

The insects of this genus are of considerable size. Their usual colours are black spotted with white. They inhabit the African deserts, and are not altogether unknown in those parts of Asia which extend from the Red Sea to Bengal. According to Leschenhault de Latour, they emit a caustic fluid when handled. In the males of some species the thorax is dilated and bilobed posteriorly. Both sexes are destitute of wings. Dejean's Catalogue contains seventeen species, all of which, except one, are African.

A. *maxillosa*, Lat. Black and smooth. Mandibles very long. Thorax bilobed posteriorly. This is a large insect from the Cape of Good Hope. It measures nearly two inches in length.

A. *decemguttata*, Dej. (Plate CCXXI. fig. 8.) Usually black above, the eyes brownish, a small white spot on each side of the anterior portion of the thorax. The elytra have each four deep grooves, with another in the centre common to both. These grooves are garnished with an ash-coloured or brownish down, which sometimes entirely disappears, and then each groove exhibits two rows of small excavated spots, with a longitudinal and slightly elevated line in the centre. Each elytron has also five spots formed of whitish down,—the first near the base of the exterior margin; the second a little in advance of the middle, in the second groove; the third and fourth rather behind the middle, and on the same line, in the first and third grooves; the fifth near the exterior margin, at the extremity between the second and third grooves. The under parts of the body and feet are of a more shining black. The thighs are sometimes reddish brown.

This species is extremely common at the Cape of Good Hope. It is subject to great variation in its markings, and has been described under various names in its different conditions. According to Dejean, the *Anthia quadriguttata*, Fab. which we have figured in this work (Plate CCXXI. fig. 3), is nothing more than a variety of the above, with three of the spots effaced from each elytron.

GENUS GRAPHIPTERUS,[2] Lat. Last article of the palpi cylindrical. Antennæ filiform, much shorter than the body. Labrum projecting, rounded, and nearly covering the mandibles. No tooth in the centre of the emargination of the mentum. Anterior tarsi not sensibly dilated in the males. Body large and flattened. Thorax heart-shaped. Elytra plane, broad, of a slightly elongated oval, more or less suborbicular.

We owe to Latreille the dismemberment of these insects from the *Anthiæ*, with which they were combined by Fabricius. However, they are equally apterous, inhabit the same parts of the world, and exhibit analogous colours. Although several insects of the north of Africa have been discovered in Italy and the south of Spain, the warmer countries of Europe have as yet been sought in vain for any species of either of the genera just named.

G. *multiguttatus*, Dej. (Plate CCXXI. fig. 7.) Dull black above, of a brighter black below. Thorax margined with white. The elytra with a sinuous margin of white, and eight spots on each of the same colour.

This species was brought by Olivier from Egypt, and given to his friends and correspondents under the above name, although it certainly does not agree with the description of the insect so named by the author in his *Entomologie* and the *Encyclopédie Méthodique*.

GENUS APTINUS, Bonelli. Terminal article of the palpi rather larger than the preceding, and slightly enlarged towards the extremity. Antennæ filiform. Labrum short, and leaving the mandibles exposed. No tooth, or a very small one in the centre of the emargination of the mentum. The first three articles of the anterior tarsi sensibly dilated in the males. Thorax heart-shaped. Elytra oval, increasing in breadth towards their extremity.

This genus greatly resembles *Brachinus*, with which it was combined by Fabricius, and with which it is still frequently confounded.[3] All the species belong to Africa (chiefly the Cape district) and the southern parts of Europe. Like the Brachini, they occur in groups under stones, and affect mountainous situations. They are similarly characterized by their power of emitting a penetrating vapour. The larger species inhabit tropical climates. The *A. balista*, Dej. measures from five to eight lines in length. It is black, with a fulvous throat and truncated elytra. It occurs in Navarre, and various parts of Spain and Portugal. A smaller species, of a deep black, with sulcated elytra, the antennæ and palpi fulvous, the feet russet yellow, was discovered by Dejean among the eastern Pyrenees. It is extremely common under stones on the mountains in the vicinity of Pratz de Mollo, and is named *A. pyrenæus*.

GENUS BRACHINUS,[4] Weber, Fab. This genus scarcely differs from the preceding. It is, however, characterized by the possession of wings, the anterior tarsi are not usually dilated in the males, the truncation of the elytra is rather square than oblique, and these parts are usually more parallel, or less enlarged at their extremities, than among the Aptini.

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[1] The name Ανθιας is bestowed by Aristotle on a fish.

[2] The name probably refers to what may be construed into an occasional resemblance of written characters upon the wings,—γϱαφω and πτεϱον.

[3] All the foreign species of the above genus in the Comte Dejean's printed *Catalogue* (1st edition) are *Brachini*.

[4] Probably from Βϱαχυνω, *I shorten*, in allusion to the truncated form of the elytra.

The Brachini, as far as yet known, have no representative in Scotland. But as the southern parts of the kingdom produce five species, we are not without hope that some of these may ere long be discovered on the northern side of the Tweed. It is, however, evidently a southern genus, for of the nineteen species of the first division of Dejean, only one, the *B. Hispanus* of Kollar, is found in Europe. It was taken at the southern extremity of Spain, by an Austrian naturalist, who happened to disembark in the bay of Algesiras in the course of his voyage to Brazil. Of the twenty-one species which constitute the second division of the genus, eight occur in Europe; and of these five are English.[1] The character by which the generality of these insects are so remarkably distinguished is, that the abdomen contains peculiar organs which secrete a caustic liquor of an extremely penetrating odour. When this is propelled by the insect on any threatened danger, it produces a detonating sound, and evaporates. M. Dumeril has remarked, that when this reservoir is opened by dissection, the liquid effervesces, and evaporates instantaneously. Paper imbued with a blue vegetable dye is changed by its action, first into a reddish hue, and then into yellow. When the vesicle which contains it is placed upon the tongue, and compressed, a peculiar and rather agreeable savour is felt in the mouth. A sharp pain, however, soon follows on the spot affected, where a yellow colour becomes perceptible, similar to that produced by a drop of nitric acid. Leon Dufour has made us acquainted with the apparatus employed in the production of this fluid.[2]

It is stated by Rowlander that the Brachini are capable of producing eighteen or twenty discharges at a time. Mr Stephens has invariably found them ready to discharge their ammunition at all times, especially when roughly handled; and Mr Cooper informed him that a specimen he met with at Cobham in the spring, performed the operation no less than thirteen times in rapid succession.[3]

B. *Jurinei*, Dej. (Plate CCXXI. fig. 6.) Testaceous. The elytra black, grooved, with the lateral margins and a central spot testaceous. From Senegal.

Genus Casnonia, Lat. Terminal article of the palpi of an oval form, almost pointed at the end. Antennæ much shorter than the body, their articulations of nearly equal length,—the first being shorter than the head. Tarsi filiform; the last article at most bifid. Thorax in the form of an elongated neck, cylindrical, and very narrow anteriorly. Head nearly lozenge-shaped, prolonged and narrowed posteriorly.

The Casnoniæ are insects of singular forms, reminding the observer of the aspect of *Raphidia* and *Apoderus*. They composed the original genus *Colliuris* of Degeer; Linnæus placed them among his *Attelabi*, while Fabricius and Herbst ranged them in the genus *Odocantha*. Latreille formed the genus in which we now place them. It is synonymous with *Ophionea* of Klug.[4] Most of the species come from America. *C. cyanocephala* occurs in Bengal.

Genus Odocantha, Fab. Characters nearly the same as the preceding. Thorax elongate oval, nearly cylindrical. Head oval, narrowed behind, but not posteriorly prolonged.

O. *melanura*, Fab. Greenish blue, the base of the antennæ, chest, and feet testaceous. The elytra testaceous, with a spot of blackish blue at the extremities. The ends of the thighs black.

Dejean retains only two species in this genus, as above defined, viz. the one just described, which is the sole British species, and *O. Dorsalis*. The former insect occurs in the temperate and colder countries of Europe, in moist and marshy places; the latter is from North America.

We pass over the genus *Zuphium*, of which one species, *Z. olens*, is remarkable for occurring in France, Spain, Italy, the southern provinces of Russia, and the East Indies,—the genus *Polistichus*, of which *P. fasciolatus* is found in Britain,—the genus *Helluo* of Bonelli, of which all the species are foreign to Europe,—the genus Drypta, which has representatives in Africa, New Holland, and the East Indies, and of which *D. emarginata* is British (for a representation of *D. ruficollis*, see Plate CCXXI. fig. 9),—the genera *Galerita, Ctenodactyla, Agra, Cymindis*, Lat. (*Tarus*, Clairville, of which *T. basalis*, Gyll. occurs in the south of Scotland), and *Calleida*.

Genus Demetrias, Bon. Hooks of the tarsi dentated beneath. Terminal article of the palpi cylindrical. The first three articles of the tarsi almost triangular, the last strongly bilobed. Body elongated. Head oval, slightly narrowed posteriorly.

These little insects, as far as we know, are all European. They are frequent in spring, on briars and hedges. We have four British species, one of which, *D. obscurus*, we owe to the recent researches of Mr Newman.

Genus Dromius,[5] Bon. Resembles the preceding; but the articles of the tarsi are entire, and nearly cylindrical. The species are apterous.

The Dromii formed part of the genus *Lebia* of Latreille, till their separation by Bonelli. They are almost all European, and are commonly found under stones, and beneath the bark of trees. Britain produces about twenty species.

Genus Lebia. Hooks of the tarsi dentated beneath. Terminal article of the palpi nearly cylindrical and oval, and truncated at the end, but never securiform. Antennæ filiform. Articles of the tarsi nearly triangular or heart-shaped, the penultimate bifid or bilobed. Body short and flat. Thorax short, transversal, broader than the head, prolonged posteriorly in the middle. Elytra broad, and nearly square.

This genus, which is comparatively numerous in European species, and is likewise known in America, and more sparingly in Africa, has been divided by Bonelli into two. The type of the first division (genus *Lamprias*) is *Leb. chlorocephala*, a beautiful little insect, of a brilliant bluish green, with the base of the antennæ, legs, breast, and thorax red, the tarsi black. It occurs occasionally near Edinburgh, and has been taken as far north as Lairig, in Sutherland. The type of *Lebia* proper is *L. crux minor*, and this second division is characterized by the penultimate joint of the tarsi being bilobed, while in the first it is said to be simple. However, as far as we are able to perceive from an inspection of our north-country specimens, there is a bilobation in that part also in *Lamprias*. But other distinctive characters will be found detailed in the works of Messrs Curtis and Stephens, both of whom follow Bonelli in regarding the two divisions as distinct genera. Dejean's *Catalogue* contains sixty-four species.

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[1] The *Catalogue des Col.* 2d ed. contains seventy-seven in all.

[2] Mém. sur le Brachine Tirailleur, *Ann. du Mus.* t. xvii. p. 70, and *Ann. des Sciences Nat.* t. vi. p. 320.

[3] Stephens' *Illustrations*, vol. i. p. 35.

[4] *Entomologiæ Brazilianæ Specimen.*

[5] From δρομευς, *a runner.*

Synoptical Table of the preceding Section, according to the system of Dejean.

TRUNCATIPENNES.

First Sub-Tribe.

- Last joint of the palpi usually ovate, and terminating nearly in a point. Claws
  - without teeth. Joints of the tarsi
    - nearly cylindrical, or very slightly triangular. The penultimate
      - not bilobed. Thorax
        - in the form of a lengthened neck, often cylindrical and contracted in front .... 1. *Casnonia.*
        - more or less ovate or rounded. Antennæ
          - covered with hairs .... 2. *Lasiocera.*
          - simple .... 3. *Odacantha.*
      - strongly bilobed .... 4. *Leptotrachelus.*
    - broad, flat, and triangular or heart-shaped. First joint of the antennæ
      - much shorter than the head .... 5. *Trigonodactyla.*
      - nearly as long as the head .... 6. *Cordistes.*
  - with teeth beneath .... 7. *Ctenodactyla.*
- Last joint of the maxillary palpi more or less securiform. Claws
  - without teeth. Penultimate joint of the tarsi
    - strongly bilobed .... 8. *Drypta.*
    - not bilobed. The three first joints of the anterior tarsi of the males
      - very much dilated .... 9. *Galerita.*
      - scarcely or not at all dilated. Last joint of the labial palpi
        - more or less securiform. First joint of the antennæ
          - as long as the head .... 10. *Zuphium.*
          - shorter than the head .... 11. *Polistichus.*
        - nearly cylindrical .... 12. *Diaphorus.*
  - with teeth beneath .... 13. *Agra.*

SECOND SUB-TRIBE.

- Claws with teeth beneath. Body
  - more or less elongate. Last joint of the labial palpi
    - strongly securiform, at least in the males. Penultimate joint of the tarsi
      - not bilobed............14. *Cymindis.*
      - bilobed............15. *Calleida.*
    - not securiform. Claws
      - with very large teeth............16. *Onypterygia.*
      - with small teeth. Penultimate joint of the tarsi
        - bilobed............17. *Demetrias.*
        - not bilobed............18. *Dromius.*
  - more or less wide, and depressed. Elytra nearly square. Last joint of the labial palpi
    - strongly securiform. Posterior margin of the thorax
      - forming a right angle with the sides............19. *Plochionus.*
      - produced in the middle............20. *Aspasia.*
    - not securiform. Posterior margin of the thorax
      - forming a right angle with the sides. Penultimate joint of the tarsi
        - not bilobed............21. *Lebia.*
        - bilobed............22. *Coptodera.*
- Claws without teeth. Antennæ
  - moniliform, or thickening towards the apex............24. *Helluo.*
  - filiform. Upper lip
    - short, transverse, and leaving the mandibles uncovered. Last joint of the labial palpi
      - not securiform. Elytra ovate,
        - more or less elongate
          - wings wanting............25. *Aptinus.*
          - winged............26. *Brachinus.*
        - scarcely elongate, nearly orbicular............27. *Corsyra.*
      - strongly securiform............28. *Drepanus.*
    - projecting, and covering the mandibles more or less. The tooth in the notch of the mentum
      - simple. Upper lip quadrate,
        - wider than long. Joints of the four anterior tarsi
          - more or less triangular or heart-shaped............29. *Dyscolus.*
          - nearly cylindrical............30. *Promecoptera.*
        - longer than broad. Elytra
          - rather short and wide, more or less square or ovate......31. *Thyreopterus.*
          - more or less elongate and parallel............32. *Catascopus.*
      - wanting. Last joint of the labial palpi
        - rather strongly securiform............33. *Eucheyla.*
        - not securiform. Elytra ovate,
          - scarcely elongate, nearly orbicular............34. *Graphipterus.*
          - more or less elongate............35. *Anthia.*

SECTION 2D, BIPARTITI, Lat. SCARITIDES, Dej.

Almost all the genera of this group (seventeen in number in the system of Dejean) were constituent portions of the old genus *Scarites* of Fabricius and Olivier. They possess several characters in common. The exterior palpi are not subulate or awl-shaped at their extremity. The elytra are not terminated by a truncation, but are either entire or slightly sinuated. The abdomen is separated from the thorax by an obvious intermediate neck-shaped portion.[1] The first article of the antennæ is always the largest. The anterior legs are often broad and palmated, and strongly notched interiorly. The anterior tarsi present no marked disparity in the sexes, and are unprovided with brushes beneath; but simply ciliated.[2]

In the *Coléoptères d'Europe* of MM. Latreille and Dejean, the Scaritides seem to be regarded as not carnivorous. But in opposition to this opinion, so contrary to analogy, we have the authority, as Mr Macleay has noted, of two accurate observers, MM. Olivier and Lefebre de Cerisy. The latter, who resides at Toulon, possesses peculiar facilities for acquiring a knowledge of their natural habits. He states them to be nocturnal insects of prey, which, during the day, lurk motionless in holes of the earth, and sally out at night to attack Melolonthidæ and other insects.[3]

The insects included in this division are rather strongly distinguished from the conterminous groups. As they are destined to live chiefly beneath the surface of the earth, their structure is more peculiarly adapted than that of the other Coleoptera to a subterranean mode of life. The body is narrow, the anterior thighs thickened, the tibiæ dilated, and furnished with strong spines, presenting a broad surface, well fitted to remove the soil;—the head and thorax are strong, and the latter is attached to the abdomen by a short peduncle or footstalk. In the last-mentioned particular they differ from most other pentamerous beetles, which usually have the thorax closely applied to the abdomen, and the hinder angles rectangular or even salient, which necessarily prevents any considerable degree of lateral motion. But in insects which excavate holes scarcely exceeding their body in width, some provision is necessary to enable them to turn their anterior portion in different directions, otherwise their progress would be nearly in a straight line. This object, which is analogous to that which is provided for in moles and other burrowing quadrupeds, by the flexibility of the vertebral column, is attained by the interposition of a narrow cylindrical piece between the abdomen and thorax, on which the latter moves as on a pivot, its hinder angles being rounded off that its motions may be performed with greater facility. The form of the antennæ is likewise in beautiful accordance with the habits of the insects. They are composed of nearly globular articulations attached to each other by a slender filament, bearing some resemblance to a series of beads rather loosely strung. By a structure of this kind, they are rendered greatly more pliant and flexile than in the other Pentamera (the joints of the antennæ in which are generally conical), and therefore present no obstacle to the insect's progress through a resisting medium.[4]

These insects are usually of a uniform black colour. The larva of *Ditomus bucephalus*, the only one that has been attended to, presents, according to Latreille, the same form and habits of life as those of *Cicindelæ*. They are more particularly characteristic of torrid countries, although Great Britain and the rest of Europe produce several genera.

GENUS ENCELADUS, Bon. *Scarites*, Oliv. Mentum inarticulate, soldered, covering almost all the under part of the head, strongly notched, with a bifid tooth in the centre. Terminal article of the labial palpi distinctly securiform. Antennæ filiform; the first article a little longer than the others.

The species of this genus differ from most of their section in having their anterior tibiæ unemarginate, which allies them to the *Simplicimanes* of Dejean, or *Grandipalpi* of Lat. The example figured, *E. gigas* (see Plate CCXXI. fig. 4), is a large insect of which the locality seems doubtful. Latreille believed it to come from Madagascar and equinoctial Africa, while Dejean regards it as South American.

GENUS ACANTHOSCELIS, Lat. *Scarites*, Fab. Mentum articulated, almost plane, strongly trilobed. Labrum very short, tridentated. Mandibles large, advanced, strongly toothed interiorly. Terminal article of the labial palpi almost cylindrical. Antennæ moniliform; the first article very large; the others much less, but enlarging insensibly towards the extremity. Body short and convex. Thorax convex, transverse, almost square. Elytra short, and very convex. Anterior tibiæ strongly palmated; posterior short, broad, arched, and spinous. Trochanters almost as large as the posterior thighs.

This genus is formed upon *Scarites ruficornis* of Fab. (Plate CCXXI. fig. 17), an insect above eight lines in length, black, with the palpi and antennæ ferruginous. It is native to the Cape of Good Hope.

GENUS SCARITES,[5] Fab. Mentum articulated, concave, strongly trilobed. Labrum, mandibles, and terminal article of the palpi as in the preceding genus. Body rather elongated, cylindrical, or slightly flattened. Thorax convex, almost crescent-shaped, notched anteriorly, rounded posteriorly, and frequently somewhat prolonged in the middle. Anterior tibiæ strongly palmated, posterior simple. Trochanters much shorter than the posterior thighs.

The insects of our present genus are of considerable size, of a black colour, usually shining, and are characteristic of sandy countries near the sea coast, or of districts impregnated with saline particles. They occur in the warmer countries of Europe, Asia, Africa, and America. Dejean enumerates fifty-eight species. Three are said to occur in Britain, *S. Beckwithii* of Stephens, *S. subterraneus*, and *S. lævigatus*, Fab. The two latter are, however, doubtful natives. The second is in fact an American insect (see Plate CCXXI. fig, 10),—the third is frequent in the south of France, and along the Mediterranean shores.

GENUS CLIVINA,[6] Lat. *Scarites*, Fab. Mentum articulate, concave, and trilobed. Labium slightly advanced, and cut almost square. Mandibles slightly projecting, not toothed interiorly. Terminal article of the labial palpi almost cylindrical. Antennæ moniliform; the first article as long as the two succeeding united. Body more or less elongated. Thorax square or globular. Anterior tibiæ almost always palmated.

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[1] The foreign genus *Ozæna*, in which the peduncle is scarcely perceptible, may be regarded as an exception to the last-named character.

[2] *Species Général*, t. i. p. 355.

[3] *Annulosa Javanica*, No. i. p. 24.

[4] *Entomologia Edinensis*, p. 77.

[5] From Σκαριζῶ, *I run swiftly.*

[6] *Clivina* is the name of an augurial bird mentioned by Pliny.

These small insects are usually found under stones, by the banks of rivers, and elsewhere. They are common all over Europe, more especially in its southern parts. They also occur in Africa, America, and the East Indies. We have two British species, *C. fossor*, Gyllenhal, which is brownish black, with the mouth, antennæ, and legs rufous, the elytra punctate striate, of the same colour as the thorax,—and *C. collaris* of Herbst, of which the head and thorax are brownish black, and the elytra chesnut colour. Dejean regards the one as a variety of the other. They are described as distinct by English entomologists. We lately found a rare and interesting species, *C. arctica*, on the mountain range on the north side of the valley of Clova, in Forfarshire. It is known to occur, though rarely, in Lapland, the north of Sweden, Finland, and sometimes as far to the east as the environs of St Petersburg. It forms the genus *Leiochiton* of Curtis,[1] so named from λειος, *smooth*, and χιτον, *a covering*, the upper surface and other parts being remarkable for glossiness.

The genus *Dyschirius*, Bonelli (named from δυς, *two*, and χιϱας, *a division of the foot or leg*), which some authors do not admit as distinct from *Clivina*, contains those species of which the thorax is globular, and the anterior tibiæ palmated only at the extremity, and simple exteriorly. Sixteen species are found in Britain.[2]

GENUS DITOMUS, Bon. Mentum articulated, concave, and trilobed. Labrum slightly notched. Labial palpi slightly elongated, the terminal article almost cylindrical. Antennæ filiform, the articles elongated and nearly filiform. Thorax cordiform or crescent-shaped. Anterior tibiæ not palmated.

This genus was established by Bonelli on the *Scaurus sulcatus*, and certain *Carabi* of Fabricius, which Rossi and Olivier had placed in *Scarites*. The species are of middle size, dark or blackish in their colouring, and frequently deeply punctured. They inhabit the southern parts of Europe, the north of Africa, and the west of Asia. We have figured *D. violaceus* on the plate last referred to, fig. 16. *D. fulvipes* of Lat. a common insect in the south of France, and occurring, though rarely, as far north as Paris, has some claims to be regarded as a British species. We are acquainted with eighteen species in all.

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[1] *British Entomology*, vol. viii. p. 346. Of the genus *Clivina*, including *Dischirius*, &c. Dejean's *Catalogue* enumerates forty-four species.

[2] We take our indications of the amount of indigenous species from Mr Stephens' *Nomenclature of British Insects*. Second edition. 1833.

Synoptical Table of the preceding Section (SCARITIDES), *according to the system of Dejean.*

- Mentum inarticulate,
  - nearly covering the under side of the head. Inner side of the anterior tibiæ
    - without a notch…… 1. *Enceladus.*
    - strongly notched…… 2. *Siagona.*
  - leaving uncovered a great part of the mouth,
    - broad, very short, and without a perceptible tooth in the centre of its notch…… 3. *Coscinia.*
    - rather narrow, short, and trilobed…… 4. *Melænus.*
- Mentum articulate, leaving great part of the mouth uncovered. Anterior legs
  - palmated. Mandibles
    - strongly dentate on the inner side. Thorax
      - convex, rounded behind, and often a little produced in the middle. Posterior tibiæ
        - straight and nearly simple…… 5. *Scarites.*
        - short, broad, bent, and covered with spines…… 6. *Acanthoscelis.*
      - quadrate, and nearly cylindrical…… 7. *Scapterus.*
      - broad, flat, nearly heart-shaped, emarginate posteriorly…… 8. *Pasimachus.*
    - very slightly or not at all dentate internally,
      - projecting greatly. Last joint of the labial palpi
        - elongate and pointed…… 9. *Oxystomus.*
        - nearly cylindrical. Thorax nearly
          - square, and somewhat cylindric…… 10. *Oxygnathus.*
          - heart-shaped, and rather flat…… 11. *Camptodontus.*
      - projecting very little…… 12. *Clivina.*
  - not palmated. Antennæ
    - short and nodose. Joints of the antennæ
      - distinct, and scarcely thickening towards the apex…… 13. *Morio.*
      - scarcely distinct, and thickening perceptibly towards the apex…… 14. *Ozæna.*
    - filiform, the joints elongate and nearly cylindrical. Labial palpi
      - somewhat elongate. Anterior tarsi
        - dilated in the males…… 15. *Carterus.*
        - alike in both sexes…… 16. *Ditomus.*
      - much elongate…… 17. *Apotomus.*

Coleoptera Pentamera.

SECTION 3D, QUADRIMANI, Lat. HARPALICI, Bon.

In this division Latreille includes those groups of Carabici which, resembling the preceding in the pointed termination of the elytra, have the four anterior tarsi dilated in the males; the first three or four articulations are in the form of a reversed heart or triangle, and are nearly all terminated by acute angles; their under part is usually furnished (excepting the *Aphoni*) with two ranges of papillæ or scales, with an intermediate linear space. The body is always winged, generally oval and arched, or convex above, with the thorax broader than long, or at most nearly isometrical, square, or trapezoidal. The head is never suddenly contracted posteriorly. The antennæ are of equal thickness throughout, or are slightly and insensibly enlarged towards the extremity. The mandibles are never remarkably strong. The external palpi are terminated by an oval or fusiform joint of greater length than that which precedes it. The tooth of the notch or emargination of the mentum is always entire,—in some wanting.[1] The legs are robust, the tibiæ spiny, and the hooks of the tarsi simple. The intermediate tarsi, even in the females, are short, and, with the exception of the dilatation, are formed nearly like the anterior. The species prefer warm and sandy situations exposed to the sun.

GENUS HARPALUS, Lat. Dej. (PLATE CCXXI. fig. 11.) The first four articles of the four anterior tarsi strongly dilated in the males, broader than long, and very decidedly triangular, or cordiform. Terminal article of the palpi somewhat elongated, slightly oval, or almost cylindrical and truncated at the extremity. Antennæ filiform. Labrum in the form of a transverse square. Mandibles slightly advanced, arcuated, and not very sharp. A simple tooth, more or less developed, in the middle of the emargination of the mentum. Body oblong, more or less elongated. Head more or less rounded, narrowed posteriorly. Thorax more or less square, cordiform, or trapezoidal. Elytra more or less elongated, and almost parallel.

The genus *Harpalus* of Latreille, as conceived in his *Genera Crustaceorum et Insectorum*, comprised all those insects which Dejean has united in the tribes *Harpaliens* and *Feroniens*, and the genera *Callistus, Oodes, Chlænius, Epomis*, and *Dinodes*, of the *Patellimanes* of the latter author. Bonelli, in his *Observations Entomologiques*, reduced the genus to the insects which now constitute the tribe *Harpaliens* of Dejean, itself consisting of twenty-eight genera. The *Harpalidæ* of the British writers include, besides our present genus, many genera of the sections afterwards mentioned under the names of *Simplicimani* and *Patellimani*.

The genus Harpalus, even as now restricted and above defined, is very extensive, and probably contains nearly one half of the species of the section. The larvæ of these insects, as far as we are acquainted with them, dwell beneath the ground. Their form is conico-cylindrical; their head large, armed with strong mandibles, resembling those of the perfect insect; the posterior part of their body exhibits a membranous tube, terminated by a prolongation of the anal region, and two fleshy articulated appendages. Their metamorphoses are likewise subterranean. The Harpali are distributed over all the earth. They are, however, obviously more abundant in the temperate and even boreal regions of the northern hemisphere, than in equinoctial or southern countries. Comte Dejean's collection contains 179 species, while Mr Stephens enumerates (including the doubtful kinds) 58 species as indigenous to Britain, besides 15 *Ophoni*, which Dejean combines with Harpalus.

We may name as one of the most abundant of the genus *H. ruficornis*, of a pitchy-black colour, the antennæ and legs rufous, the elytra pubescent striated, the interstices punctured. This insect is spread over all Europe. We took it at Cape Wrath. It occurs in Siberia. M. Goudot brought it from Northern Africa.

H. æneus is distinguished by various shades of green above, with a brassy or coppery lustre; the under side black; external margin of the elytra punctulated, the antennæ and legs rufous. This species is extremely variable. It is generally of a rich bronzed green; the males highly polished, the females more obscure, sometimes brownish black. Mr Kirby once took a specimen of this insect, which he immersed in hot water, and was surprised to observe what he at first supposed an intestine thrust itself forth; on a nearer inspection he found it was an intestinal worm, thicker than a horse-hair, and of a brown colour.[2]

This group (the Quadrimani), in the system of Dejean (where it is named Harpaliens), includes many minor genera not recognised in the *Règne Animal*, and contains the genera *Tetragonoderus* and *Pelecium*, which in Latreille's arrangement belong to other sections. As we cannot enter into a detailed exposition of the characters of those genera, we shall here exhibit Dejean's latest views by means of a synoptical table.

HARPALICI.

FIRST SUB-TRIBE.

Mentum trilobed.

Antennæ	filiform	1. *Pelicium.*
	moniliform	2. *Eripus.*

SECOND SUB-TRIBE.

Mentum deeply notched.

This sub-tribe may be separated into two divisions.

FIRST DIVISION.

Antennæ moniliform.

The tooth in the notch of the mentum	simple. Last joint of the labial palpi	ovate	3. *Cratocerus.*
		cylindric, and truncated at the extremity	4. *Somoplatus.*
	wanting		5. *Daptus.*

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[1] The ligula or anterior portion of the mentum is always, according to Latreille, in this as well as in the two following genera, remarkably salient, obtuse or truncated at the end, and is accompanied by two distinct membranous paraglossæ in the form of auricles (oreillettes).

[2] For the other British species we must refer the reader to the works of Messrs Stephens and Curtis. We have described such as occur near Edinburgh in our *Entomologia Edinensis*. The characters of the foreign kinds are detailed in Dejean's *Species Général*.

Second Division.

Antennæ filiform.

May be divided into two subdivisions.

First Subdivision.

Notch of the mentum with a bifid tooth in the middle.

- Body
  - flat and rounded..6. *Cyclosomus.*
  - elongate..7. *Promecoderus.*

Second Subdivision.

Tooth in the notch of the mentum simple or wanting.

- Last joint of the palpi securiform..8. *Axinotoma.*
- Last joint of the palpi not securiform. The four first joints of the intermediate tarsi of the males
  - more or less triangular or heart-shaped. Last joint of the palpi
    - more or less cylindric or ovate, and truncated at the extremity. Fourth joint of the four anterior tarsi of the males
      - triangular or heart-shaped. Head
        - more or less quadrate or triangular, not contracted behind. The tooth in the notch of the mentum
          - more or less obvious. Upper lip
            - emarginate. The tooth in the notch of the mentum
              - obtuse..9. *Acinopus.*
              - strong and very acute..10. *Cratacanthus.*
            - quadrate..11. *Paramecus.*
          - wanting. Mandibles
            - more or less pointed. Upper lip
              - deeply notched..12. *Cratognathus.*
              - almost quadrate..13. *Agonoderus.*
            - obtuse, and not salient..14. *Barysomus.*
        - more or less rounded and triangular, and contracted behind. The tooth in the notch of the mentum
          - wanting. Mandibles
            - obtuse, and not salient..15. *Amblygnatus.*
            - more or less pointed. Four first joints of the anterior tarsi of the males
              - obviously dilated. First joint of the four anterior tarsi of the males
                - as wide as the following. Last joint of the palpi
                  - ovate and almost inflated. First joint of the anterior tarsi of the females
                    - not dilated...16. *Platymetopus.*
                    - dilated.......17. *Gynandropus.*
                  - cylindric, or very slightly ovate 18. *Selenophorus.*
                - smaller than the following..19. *Anisodactylus.*
              - very slightly dilated..20. *Bradybænus.*
          - more or less obvious. Mandibles
            - salient and pointed..21. *Geodromus.*
            - projecting but little. The four first joints of the intermediate tarsi of the males
              - obviously dilated. The four first joints of the four anterior tarsi of the males
                - as long as wide, and slightly triangular..22. *Hypolithus.*
                - wider than long, and distinctly triangular or heart-shaped. First joint of the anterior tarsi of the females
                  - dilated..23. *Gynandromorphus.*
                  - not dilated..24. *Harpalus.*
              - very slightly dilated..25. *Geobænus.*
      - deeply bilobed..26. *Stenolophus.*
    - terminating in a point..27. *Acupalpus.*
  - broad and nearly square..28. *Tetragonoderus.*

SECTION 4TH, SIMPLICIMANI.

This section resembles the preceding so far as regards the termination of the elytra;[1] but the two anterior tarsi only are dilated in the males, without however forming a square or orbicular pallet; sometimes the first three articles are obviously broader, and the succeeding one is in that case always much less than its antecedent; sometimes the latter and the two preceding ones are larger, almost equal, and in the form of a reversed or triangular heart. The joints of the four following tarsi are more slender and elongated, almost cylindrical, or in the form of a lengthened and reversed cone.

The *Simplicimani* of Latreille consist of genera belonging to the tribe *Carabiques Feroniens* of Dejean, with the addition of *Tetragonoderus*, Dejean (Harpalici), *Catascopus*, Kirby (Truncatipennes), and a few others.

GENUS ZABRUS, Clairville. The first three articles of the anterior tarsi dilated in the males, broader than long, strongly cordiform. Terminal article of the palpi almost cylindrical, and truncated at the extremity. Antennæ filiform, and but slightly lengthened. Labrum of a square form, broader than long, slightly notched anteriorly. Mandibles little advanced, rather strongly arcuated, almost obtuse. A simple tooth in the middle of the emargination of the mentum. Body thick and convex. Thorax transverse, square, trapezoidal, or rounded on the sides. Elytra convex, rarely elongated, frequently very short, almost parallel, and rounded at the extremity.

These insects are usually found under stones, or marching about the fields, occasionally on the stalks of grass or other herbage. We are acquainted with about twenty species, of which not more than two are British. The majority of the others occur in the southern parts of Europe. There is one from Teneriffe.

GENUS FERONIA, Lat. Dej. The first three articles of the anterior tarsi dilated in the males, broader than long, and strongly triangular or cordiform. Terminal article of the palpi more or less elongated, cylindrical, or slightly securiform. Antennæ filiform, more or less lengthened. Labrum square, broader than long, sometimes almost transversal, quadrate anteriorly, or slightly notched. Mandibles more or less advanced, and more or less arcuated and pointed. A bifid tooth in the middle of the emargination of the mentum. Thorax more or less cordiform, rounded, square, or trapezoidal, never transverse. Elytra more or less elongated, oval, or parallel. Intermediate tibiæ always straight.

A great variety of opinion is maintained by entomologists regarding the distribution of the component parts of this extensive genus. Bonelli, in the synoptical table annexed to the first part of his *Observations Entomologiques* (in 1809), published the generic characters of *Platysma, Pœcilus, Abax, Molops, Percus, Melanius*, and *Pterostichus*. At an after period MM. Megerle and Ziegler established *Argutor, Steropus, Cophosus*, and *Omaseus*, the latter genus, it is believed, corresponding to *Melanius* of Bonelli. All these were admitted provisionally into the first edition of Comte Dejean's *Catalogue*, published in 1821. In the third volume, however, of the *Species Général* of that great collector, he observes as follows: "Ma collection depuis cette époque s'etant considérablement augmentée, je me suis trouvé souvent tres-embarassé pour placer dans ces différents genres les espèces qui je recevais, surtout les exotiques, et quelquefois plusieurs d'entre elles me paraissaient intermédiaires entre deux genres, et appartenir autant à l'un qu'à l'autre. Plus je recevais d'insectes, plus je me trouvais embarassé, et lorsque je voulus classer definitivement toutes mes espèces dans chaque genre, et etablir les caractères de chacun de ces genres, après plusieurs essais infructueux, je finis par être convaincu que cela était réellement impossible." Dejean then thought of following the example of Sturm, who reduces (in his *Deutschlands Fauna*) all the genera above named to those of *Abax, Molops, Pterostichus*, and *Platysma*; but after a deliberate re-examination, even these did not appear sufficiently marked; and he finally determined to combine them all in one under the name of FERONIA, a term previously used in a comprehensive sense by Latreille in the first edition of the *Règne Animal*.

The genus *Feronia*, then, of Dejean is one of the most extensive in the coleopterous order, containing above 230 species. It is subdivided by the last-named author into ten sections, corresponding to the same number of genera as established by Bonelli, Megerle, Ziegler, and Sturm.

According to Latreille's views, the genus is divisible into three groups as follows: 1*st*, The species, generally winged, of which the body, more or less oval, is a little convex or arcuated above, with the antennæ more filiform, the head proportionally narrower, and the mandibles somewhat less projecting. In their habits these insects approach the genera *Harpalus* and *Zabrus*. Such are the *Amaræ*, of which the thorax is transverse (and which Dejean admits as a distinct genus); the *Pœcili*, where it is almost as long as broad, and where the rather short antennæ have the third article compressed and angular; and the *Argutores*, which resemble the Pæcili, but have proportionally shorter antennæ, with the third joint not angular.

2*d*, The species usually furnished with wings, but of which the body is straight, plane, or horizontal above, with the head nearly as wide as the body. Such is the genus *Platysma* of Bonelli, to which Latreille unites *Omaseus* of Ziegler and Dejean, and *Catadromus* of Macleay.

3*d*, This division contains Feroniæ, analogous to those of the preceding one in their general characters, but distinguished by the want of wings.[2]

We shall conclude by observing that our English entomologists have adopted all those minor genera, in so far as they are applicable to the British species, and have even proposed several others of still more limited application. We regret that our necessarily narrow limits prevent our entering into minute details.[3] We shall merely indicate a few of the species. *F. madida* is shining black, the elytra ovate, rather convex, subpunctate-striate, with a puncture on the third interstice a little behind the middle. This is the *F. concinna* of Sturm and Dejean. A variety occurs with the thighs and sometimes the tibiæ rufous; it constitutes the *F. madida* of the latter author. They are not distinct. Both varieties are in this country among the most common of coleopterous insects, occurring beneath stones, at the roots of trees, &c. both on low grounds and on mountains. They seem less common in Germany than in any other country in Europe. *F. nigrita* is also of frequent occurrence in all parts of Britain. It is of a shining black, the thorax subquadrate, narrowed behind, the elytra with obsoletely punctured striæ, and three impressed dots on the disk. *F. orinomum* is likewise shining black, often faintly tinged with brassy; elytra striated, with more than four impressed dots on the disk of each. By the comparison of an extensive series of specimens of this insect which we have collected in various parts of Scotland, we are satisfied that *F.* (*Omaseus*) *Bulwerii* of Stephens is not specifically distinct. A species frequent under stones in woods and fields, and the last which we shall here mention, is *F. melanaria.* It is black, apterous, moderately convex, the thorax with a bistriated fovea in each of its posterior angles, the elytra with striæ nearly impunctate.

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[1] As usual, there are exceptions to the rule:—"Plusieurs Carabiques simplicimanes," says Latreille, "ont l'extrémité de leurs élytres fortement sinuée au bout, et se distinguant à peine, sous ce rapport, des *Troncatipennes*." (Note to *Règne Animal*, t. iv. p. 399.)

[2] For a further exposition of Latreille's views, see *Règne Animal*, tom. iv. p. 395.

[3] For the arrangement of the indigenous species, see Mr Stephens' *Nomenclature of British Insects*, 2d edition.

Genus Broscus, Panzer. *Cephalotes,* Bon. First three articles of the anterior tarsi dilated in the males, broader than long, and decidedly cordiform. Terminal article of the labial palpi elongated and slightly securiform. Antennæ filiform, and but slightly lengthened. Labrum of a square form, broader than long, almost transverse. Mandibles slightly arcuated, and rather sharp. A simple tooth in the middle of the emargination of the mentum. Thorax cordiform, convex, and much contracted posteriorly. Elytra rather long, slightly oval, or parallel.

This genus was established by Bonelli on the *Carabus cephalotes* of Fabricius, and was also distinguished about the same period by Panzer under the name of *Broscus.* We adopt the latter term as more familiar to the English collectors. Of the five species with which we are acquainted, two belong to Europe, one to the north of Africa, one to Mount Sinai, and the fifth to Asia Minor. They are all of considerable size, and bear a resemblance to the genus *Steropus* of Megerle.

The only British species is *B. cephalotes,* which is of an elongated form, black, with the head thinly punctured, and the elytra very finely punctate-striate. It occurs in sandy places over many parts of Britain; and in the vicinity of Edinburgh is plentiful under stones, and marine rejectamenta, on the shore between Portobello and Musselburgh. We found it as far north as Keoldale, near Cape Wrath. The attitude this insect assumes when disturbed is rather peculiar. The two anterior pair of legs are brought close together, and extended straight outwards at right angles with the under surface of the body. The hind legs are bent upwards, and project in a similar way from the opposite surface. The antennæ are drawn close to the sides of the thorax, and the mandibles extended to their utmost stretch, while a considerable degree of rigidity is imparted to the whole. It takes this posture most readily in cold weather; at other times, when more active, it prefers seeking safety by flight, or by burrowing in the sand.[1]

"The habit of these insects," it is elsewhere observed, "is very curious. They are found only in the sand on the sea shore, and live in dens about three inches deep and half an inch wide, which are made in a diagonal position in the sand, where it is mixed with decomposed stalks of *Elymus arenarius.* They appear to rove during the day occasionally; but upon any alarm they run swiftly to their dens, projecting from the mouths of which their heads may be seen watching for prey. On holding another beetle to the hole, the one within would immediately seize hold of it with its jaws, and continue so tightly fixed as to suffer itself to be drawn out without quitting its hold. They appear to be very ferocious insects; and, from the number of elytra and other parts strewed about the sand, it may be supposed that they prey on each other."[2] The latter observation, we may remark, applies to many insects; although the human race (certainly in that respect the most noted) have been supposed to present the only instances of identical species waging war upon each other.

> Even tiger fell and sullen bear,
> Their likeness and their lineage spare.
> Man only mars kind nature's plan,
> And turns the fierce pursuit on man.[3]

The natural position of the genus Broscus seems to be that assigned it by Mr Curtis, between the Scaritides and the species which in the *Entomologia Edinensis* is placed at the head of the genus *Feronia,* viz. *F. madida* (*Steropus madidus,* Meger.). In common with the former, *Broscus* possesses an elongated form, rather short stout legs, and a pedunculated thorax, which adapt it to a subterraneous mode of life. In the latter the thorax is also pedunculated, and the legs thick and strong, while the more rigid structure of the antennæ, admitting less easily of being applied to the sides of the thorax to facilitate progression in a cylindrical hole, together with the general configuration of most of the other parts, assimilate it more decidedly to the other Feroniæ, to which its habits perfectly correspond.

Genus Mormolyce, Hagenbach.[4] Exterior palpi very short; the terminal article cylindrical, and almost rounded at the extremity. Antennæ setaceous, almost as long as the body; the third article as long as the two following. Labrum almost square, notched anteriorly. Mandibles short, arcuated, rather sharp, and toothed interiorly. A simple tooth in the middle of the emargination of the mentum. Body remarkably depressed. Head narrow, elongated, much prolonged posteriorly. Thorax almost lozenge-shaped. Elytra flat, thin, greatly dilated, much wider and longer than the abdomen.

The aspect of this genus is one of the most remarkable with which we are acquainted. We place it among the *Simplicimani* (*Feroniens*) in accordance with the example of Latreille and Dejean, the latter of whom observes, "J'ai placé cet insecte près des *Sphodrus,* mais ce n'est qui provisiorement, car j'ignore de quelle maniere les tarses sont dilatés dans les males, et même s'ils ne sont pas semblables dans les deux sexes." In regard to its locality he further observes, "D'après M. Hagenbach, elle se trouve dans la partie occidentale de Java; d'autres personnes croient qu'elle vient de la Cochin-Chine."[5] Our recent acquisition of an extensive series of specimens of the only known species enables us to determine both of those doubtful points. The tarsi are alike in both sexes, and our collection was brought from Java.

The insect above alluded to (*Mormolyce phyllodes,* Plate CCXXI. fig. 13[6]) measures nearly three inches in length and an inch and a half across the dilated portion of the elytra. It is entirely of a blackish-brown colour, somewhat paler on the edges of the abdomen. It is furnished with wings, and the elytra have the appearance of being reticulated. The figure just referred to will convey an accurate idea of its form. We have supplied the principal collections of Europe with this rare and singular insect, of which, says Dejean, to whom we had the pleasure to transmit a pair, "il est presque impossible de se faire la moindre idée par la description." He also terms it "un insecte extraordinaire, qui parait appartenir au premier aspect à la famille des *Mantis,* mais qui est cependant un Coléoptère, et même un veritable Carabique, ainsi qu'il est facile de s'en convaincre par ses caractères generiques."

Passing over the genus *Sphodrus,* of which *S. leucophthalmus* is the only British species, we come to

Genus Calathus, Bon. First three articles of the

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[1] *Entomologia Edinensis,* p. 82.

[2] *Entomological Magazine,* No. 1, p. 92.

[3] *Rokeby,* canto iii.

[4] *Mormolyce Novum Coleopterorum Genus,* Nuremberg, 1825.

[5] *Species Général,* t. v. part 2, p. 714.

[6] The parts of the mouth are represented on the same plate, fig. 12, *a, b, c, d.*

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anterior tarsi dilated in the males. Hooks of the tarsi toothed beneath. Terminal article of the palpi elongated, almost cylindrical, and truncated at the extremity. Antennæ rather elongated, filiform, and slightly compressed. Labrum of a square form, broader than long, very slightly notched anteriorly. Mandibles not much advanced, slightly arcuated, and rather sharp. A bifid tooth in the middle of the emargination of the mentum. Thorax trapezoidal, or almost square, little, if at all, contracted posteriorly. Elytra rather elongated, slightly oval, little contracted anteriorly, and rounded at the extremity.

This genus, as Mr Stephens observes, presents a peculiar outline from the shape of the head, trapeziform thorax, and elliptic elytra, by which it is readily distinguished from the neighbouring genera. The species usually reside among short herbage on banks, and are frequently observed upon quick-hedges.[1] They are generally of a black or brown colour, rarely metallic. They are extremely active in their movements. The only species we shall here notice is the *C. microcephalus* of Dejean,[2] which we discovered in the summer of 1832 in the highlands of Forfarshire, Perthshire, and Aberdeenshire. It forms an addition to our British species, and is distinguishable from the others by the following characters:—Shining black; antennæ, palpi, legs, and margin of the thorax testaceous; the thorax rather long, somewhat narrowed behind, with the hinder angles obtuse; elytra not much elongate, with slender impunctate striæ, the second and third from the suture with two impressed points. In size it nearly agrees with the very common *C. melanocephalus*. On the continent it occurs in Sweden, France, Switzerland, and Germany, chiefly in woods and on mountains.

Here follows the synoptical table of the preceding section, according to the system of Dejean, and including many genera of which we cannot give the detailed characters.

FERONIENS, Dej. (Chiefly) SIMPLICIMANI, Lat.

DIVISION FIRST.

First joint of the anterior tarsi dilated, at least in the males.

This division contains only one genus........ 1. *Stenomorphus.*

DIVISION SECOND.

The two first joints of the anterior tarsi dilated in the males.

- Tooth in the notch of the mentum
  - wanting........ 2. *Omphreus.*
  - simple........ 3. *Melanotus.*
  - bifid. Last joint of the labial palpi
    - ovate, and terminating nearly in a point. Thorax
      - flat, nearly square, slightly or not at all contracted behind........ 4. *Pogonus.*
      - convex, heart-shaped, considerably contracted behind........ 5. *Cardiaderus.*
    - nearly cylindrical, truncated at the tip, and slightly securiform. Thorax
      - convex, nearly ovate........ 6. *Baripus.*
      - flat, contracted behind, more or less heart-shaped........ 7. *Patrobus.*

DIVISION THIRD.

Three first joints of the anterior tarsi dilated in the males.

FIRST SUBDIVISION.

Claws dentate beneath.

- Tooth in the notch of the mentum
  - simple........ 8. *Dolichus.*
  - bifid. Last joint of the labial palpi
    - not securiform. Thorax
      - contracted behind, and more or less heart-shaped........ 9. *Pristonychus.*
      - trapezoidal or nearly square; scarcely or not at all contracted behind........ 10. *Calathus.*
      - oval, rounded behind........ 11. *Pristodactyla.*
    - securiform........ 12. *Taphria.*

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[1] *Illus. of Brit. Ent.* vol. i. p. 98.

[2] *Species Général*, t. iii. p. 78.

Second Subdivision.

Claws without teeth.

- Third joint of the antennæ as long as the two following united. Elytra
  - much wider than the abdomen .... 13. *Mormolyce.*
  - nearly of the same breadth as the abdomen .... 14. *Sphodrus.*
- Third joint of the antennæ shorter than the two following united. Three first joints of the anterior tarsi in the males
  - considerably elongate, very slightly triangular, or nearly square. The tooth in the notch of the mentum
    - simple. Thorax more or less
      - heart-shaped; the hinder angles always distinct. Elytra
        - flat, elongate-ovate, without distinct anterior angles .... 15. *Platynus.*
        - slightly convex, ovate or elongate-quadrate; the anterior angles always distinct .... 16. *Anchomenus.*
      - rounded; without distinct posterior angles .... 17. *Agonum.*
    - wanting .... 18. *Olisthopus.*
  - scarcely elongate, distinctly triangular or heart-shaped. Mentum
    - trilobed or slightly notched. Last joint of the maxillary palpi
      - not securiform,
        - almost cylindrical, and truncated at the tip. Last joint of the labial palpi
          - triangular, or very strongly securiform .... 19. *Trigonotoma.*
          - slightly securiform. Middle lobe of the mentum
            - produced and nearly pointed .... 20. *Catadromus.*
            - scarcely produced and almost truncated .... 21. *Lesticus.*
          - almost cylindrical. Middle lobe of the mentum
            - nearly wanting .... 22. *Distrigus.*
            - rounded .... 23. *Abacetus.*
        - elongate, and terminating nearly in a point .... 24. *Drimostoma.*
      - strongly securiform .... 25. *Microcephalus.*
    - deeply notched. The tooth in the notch
      - simple or bifid. Three first joints of the anterior tarsi of the males
        - without appendages beneath. Last joint of the maxillary palpi
          - cylindric or securiform. Body
            - more or less elongate or depressed; Thorax more or less heart-shaped, rounded, quadrate, or trapezoidal. The tooth in the notch of the mentum
              - bifid. Last joint of the labial palpi
                - not securiform. Middle legs
                  - not at all or slightly arched .... 26. *Feronia.*
                  - much arched .... 27. *Camptoscelis.*
                - strongly securiform .... 28. *Myas.*
              - simple. Thorax
                - convex or heart-shaped. Mandibles
                  - wide, and projecting little .... 29. *Cephalotes.*
                  - narrow, and projecting much .... 30. *Stomis.*
                - flat and nearly square .... 31. *Abaris.*
            - short, thick, and convex; thorax transverse. Last joint of the labial palpi
              - pretty strongly securiform .... 32. *Rathymus.*
              - nearly cylindrical. The tooth in the notch of the mentum
                - bifid .... 33. *Pelor.*
                - simple .... 34. *Zabrus.*
          - slightly ovate .... 35. *Amara.*
        - furnished with appendages beneath .... 36. *Lophidius.*
      - wanting. Thorax
        - more or less square or heart-shaped, not at all or very slightly transverse 37. *Antarctia.*
        - transverse, rounded on the sides, slightly produced in the middle behind .... 38. *Masoreus.*

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SECTION 5TH, PATELLIMANI, Lat.

This section is chiefly distinguished from the preceding by the mode in which the two anterior tarsi are dilated in the males; the first joints (usually the first three, then the fourth, in others only the first two) sometimes square, sometimes partly of that form, and the others heart-shaped or reversed triangular, but always rounded at their extremity, and not terminated, as in the preceding sections, by acute angles,—form an orbicular pallet or lengthened square, of which the under surface is usually furnished with brushes or close set papillæ, without any intermediate vacancy. The legs are generally long and slender. The thorax is frequently narrower throughout its whole extent than the abdomen. The species frequent, for the most part, moist places on the banks of rivers.

In the *Règne Animal* this section is composed of the *Patellimani* of Dejean, of a portion of his *Feroniens* (Gen. *Dolichus, Platynus, Agonum, Anchomenus, Patrobus*), and of the genus *Pelicium* of Kirby, referred to the *Harpaliens* in the *Species Général*. It is subdivided by Latreille into two principal groups.

a. Head insensibly contracted behind.

GENUS AGONUM, Bon. First three articles of the anterior tarsi dilated in the males, longer than broad, and slightly triangular or cordiform. Terminal article of the palpi lengthened, cylindrical, more or less oval, and truncated at the extremity. Antennæ filiform, rather elongated. Labrum slightly convex, of a square form, broader than long, almost transversal. Mandibles not much advanced, slightly arcuated, rather sharp. A simple tooth in the middle of the emargination of the mentum. Thorax more or less rounded, without obvious posterior angles. Elytra oval, more or less elongated.

Of this genus *A. sexpunctatum* is a beautiful species, of which the head and thorax are golden green, the elytra copper-red, finely striated, and impressed with six large punctures. There is only one recorded instance of its being taken in Scotland,—on the banks of the water of Leith, a little to the west of Edinburgh.[1] Several other species are, however, common in Scotland. There are about thirty kinds in Britain; and Dejean's collection contains fifty-six.

The genus ANCHOMENUS is nearly allied to the preceding, but the labrum is plane, the thorax more or less cordiform, with obvious posterior angles. The body is not so flat. We are acquainted with above forty kinds, of which not more than five inhabit Britain. We consider *Platynus angusticollis* as belonging to this genus.

In the genus CHLÆNIUS of Bonelli, the tooth of the emargination of the mentum is bifid, the external maxillary palpi are terminated by an almost cylindrical article, slightly restricted at the base, that of the labial being in the form of a reversed and lengthened cone. There are 115 species of this extensive genus, of which about eight are as yet recognised as British. They are ornamental insects, being frequently adorned with green, and burnished with a metallic lustre. They are spread over almost all the earth,—Europe, Asia, Africa, and America. They seem, however, rare in the southern division of the new world, and, as far as we know, have not yet been found in New Holland.[2] *Carabus saponarius* of Olivier,[3] which is used in Africa instead of soap, belongs to the genus *Chlænius*. It was brought from Senegal by M. Geoffroy, fils.

In the genus LICINUS the first two articles of the anterior tarsi are dilated in the males. The terminal article of the palpi is broad and securiform, and there is no tooth in the middle of the emargination of the mentum. The species are confined to Europe and the north of Africa. In the genus BADISTER the first three articles of anterior tarsi are dilated in the males, and the terminal article of the palpi is oval. The species are confined to Europe.

b. Head suddenly contracted behind the eyes.

This division of the *Patellimani* contains the genera PELICIUM of Kirby and CYNTHIA of Lat., both from South America, and three other genera, viz. PANAGÆUS (see Plate CCXXI. fig. 15), of which the head is very small compared to the size of the body,—LORICERA (Ibid. fig. 14), of which the first joint of the antennæ is robust, almost as long as the three following united, the second and fourth short, with strong hairs, the third longer than the second, likewise furnished with hairs,—and PATROBUS.

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[1] *Ent. Ed.* p. 99.

[2] For the sectional division of this genus, see Dejean's *Species Général*, t. ii. p. 297.

[3] *Coléoptères*, t. iii. p. 35, Pl. 3. fig. 26.

Synoptical Table of the preceding Section, according to the System of Dejean.

PATELLIMANI.

- Notch of the mentum with a tooth in the middle. Anterior tarsi dilated in the males
  - at most in the two first joints. Last joint of the maxillary palpi
    - strongly securiform. The tooth in the notch of the mentum
      - simple........ 1. *Eurysoma.*
      - bifid........ 2. *Panagæus.*
    - not securiform........ 3. *Geobius.*
  - in the three first joints. The tooth in the notch of the mentum
    - simple. Antennæ
      - beset with hairs........ 4. *Loricera.*
      - simple. Last joint of the palpi
        - not securiform,
          - rather elongate, ovate, and terminating nearly in a point........ 5. *Callistus.*
          - elongate, and truncated at the tip........10. *Oodes.*
        - strongly securiform........ 6. *Vertagus.*
    - bifid. Last joint of the palpi
      - elongate, and
        - truncated at the apex........ 7. *Chlænius.*
        - strongly securiform........ 8. *Epomis.*
      - short and slightly securiform........ 9. *Dinodes.*
- Notch of the mentum without tooth in the middle. Mandibles
  - pointed. Last joint of the palpi
    - not securiform........ 11. *Rhembus.*
    - rather strongly securiform........12. *Dicælus.*
  - obtuse. Anterior tarsi dilated in the males,
    - in the two first joints........13. *Licinus.*
    - in the three first joints........14. *Badister.*

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* *

Anterior tibiæ without an emargination on the internal side, or presenting one that begins close to their extremity, or that does not extend on their anterior face, and forms merely an oblique and linear canal.

SECTION 6TH, GRANDIPALPI, Lat. SIMPLICIPEDES, Dej.

In this section of the *Carabici* the ligula is often extremely short, terminated in a point in the centre of its summit, and accompanied by pointed paraglossæ. The mandibles are robust. The terminal joint of the exterior palpi is usually larger, compressed into the form of a reversed triangle, or hatchet-shaped in some,—almost spoon-shaped in others.[1] The eyes are prominent. The elytra are entire, or simply sinuated at their posterior extremity. The abdomen is usually bulky when compared to the other parts of the body. These Carabici are for the most part of great size, often richly coloured, or ornamented with metallic splendour. They are active in their movements, and voracious in their dispositions. They are divisible into three groups.

1*st*, Body always thick, without wings; labrum always bilobed; terminal article of the external palpi always very large; emargination of the mentum toothless; internal side of the mandibles entirely dentated (or nearly so) throughout their length.

GENUS PAMBORUS, Lat. Tarsi similar in both sexes. Terminal article of the palpi securiform. Antennæ filiform. Labrum bilobed. Mandibles but slightly projecting, greatly curved, strongly toothed interiorly. Mentum almost plane, slightly notched anteriorly. Thorax almost cordiform. Elytra elongate oval.

This genus is formed upon a large insect from New Holland, the *P. alternans*, which we have represented in Plate CCXXII. fig. 1. It is the only one yet known. In a collection received some time ago from New Holland (transmitted to the Edinburgh Museum by Colonel Lindsay), and submitted to our examination by Professor Jameson, there is either a distinct species, or a strongly marked variety,—the third and fourth striæ of the elytra being much more regular than usual. Comte Dejean, with whom we communicated on the subject, regards it as a species.

GENUS CYCHRUS, Fab. Tarsi similar in the two sexes. Terminal article of the palpi very strongly securiform, almost spoon-shaped, and more dilated, in the males. Antennæ setaceous. Labrum bifid. Mandibles narrow, and toothed interiorly. Mentum strongly notched. Thorax cordiform, little, if at all, raised at the edges, and not prolonged posteriorly. Elytra fixed, carinated laterally, and embracing the sides of the abdomen.

C. *rostratus* is common all over Britain, and is sometimes taken at a great height upon the mountains. *C. elongatus* and *attenuatus* are said to occur in England. We have represented that discovered by Professor Bonelli among the mountains of the north of Italy, Plate CCXXI. fig. 22. Eleven species are known in all. They are found in Europe, Asiatic Russia, and North America.

The genus SPHÆRODERUS of Dejean is formed by dismemberment of the preceding. It is a sub-genus peculiar to America. We have represented *S. nitidicollis*, Plate CCXXI. fig. 19.

2*d*, Body thick, and mostly apterous, as in the preceding genera, but the emargination of the mentum provided with an entire or bifid tooth, and the mandibles armed at most with one or two teeth situated at their base.

GENUS PROCERUS, Megerle. Tarsi similar in both sexes. Terminal article of the palpi very strongly securiform, and more dilated in the males. Antennæ filiform. Labrum bilobed. Mandibles slightly curved, very sharp, smooth, with only a single tooth at their base. A very strong tooth in the middle of the emargination of the mentum. Thorax almost cordiform. Elytra elongate oval.

The Proceri are large and remarkable insects, the giants of the European Carabici. In regard to their colours, they are either entirely black, or black beneath, with a tinge of blue or green above. The elytra are extremely rough. They appear to inhabit exclusively the mountains and forests of Carniola, Illyria, Turkey in Europe, parts of Hungary, the south of Russia, the Caucasus, and Asia Minor. *P. Duponchelii*, Dej. was lately taken in the environs of Athens. M. Fischer is of opinion (*Entomographie de la Russie*), that *P. tauricus* (Plate CCXXI. fig. 21) and *Caucasicus* are, the former the male, the latter the female, of the same species; but Dejean now possesses both sexes of each, and regards them as distinct. The synonymes of the species, however, are still confused and contradictory.

GENUS CARABUS, Lin. Fischer, Dej. The first four articles of the anterior tarsi dilated in the males, the first three very strongly, the fourth often more slightly. Terminal article of the palpi more or less securiform, and more dilated in the males. Antennæ filiform; the third article cylindrical, and scarcely longer than the others. Labrum bilobed. Mandibles slightly curved, more or less sharp, smooth, with only a single tooth at their base. A very strong tooth in the middle of the emargination of the mentum. Thorax more or less cordiform. Elytra more or less elongate oval. Wings not fitted for flight.

The great genus *Carabus* of Linnæus originally contained the whole of those extensive natural groups which now constitute the family of Carabici, with which we are still engaged. Even as now restricted, it is one of the most numerous with which the entomologist is concerned, and is rendered highly interesting from the size and beauty of many species. The genera with which the *Carabi*, as above defined, bear the most direct relations, are *Procerus*, *Procrustes*, *Calosoma*; but, as Dejean observes, they differ from the first by the anterior tarsi, dilated in the males,—from the second by the form of the labrum and mentum,—and from the third by several characters easily perceived on comparison.

The greater proportion of the true Carabi, which form a very interesting and well-observed genus, occur in the comparatively temperate countries of Europe, the Caucasus, Siberia, Asia Minor, Syria, and the north of Africa, as far south as the 30th degree. A few are also found towards the two extremities of America, and it is not improbable that others may be ascertained to inhabit the intermediate countries.[2] A very fine species (*C. cribellatus*, Adams) is native to the polar regions of Siberia;[3] and Sir Joseph Banks captured another as far south as Terra del Fuego;[4] of the latter circumstance, Dejean, who has done so much to illustrate the family, does not appear to be aware. "Depuis long temps je supposais néanmoins qu'on devait les retrouver à l'extrémité de l'Amérique Méridionale; M. Eschscholtz, qui fait pour la seconde fois le tour du monde avec le Capitaine Kotzebue, vient de confirmer cette supposition, et dans une lettre écrite à M. le Comte de Mannerheim il lui annonce

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[1] It is often more dilated in the males than in the other sex, particularly in *Procerus*.

[2] *Règne Animal*, t. iv. p. 412.

[3] *Entomographie de la Russie*, tab. 8, fig. 13.

[4] *Introduc. to Ent.* vol. iv. p. 493.

Coleoptera Pentamera.

qu'il a trouvé au Chili un véritable Carabe."[1] None of the genus, however, has as yet been found either in Southern Africa or New Holland. Count Dejean possesses 163 species, which he has arranged in sixteen divisions. In the first thirteen are comprised all those of which the elytra are arched or convex, in the three last those in which they are plane. The nature of the surface of the elytra furnishes the other secondary characters, in pretty close accordance with the methods of Bonelli and Clairville.[2] Among the continental species, the *C. rutilans* (Plate CCXXI. fig. 20), *hispanus*, &c. exhibit perhaps the most ornamental examples within the range of the European Coleoptera; and our own *Carabus nitens*, an inhabitant of the heathy wastes, yields to few, even of the exotic species, in its lustrous and metallic splendour.

The name of Carabus (Καραβος), applied generically by Linnæus to so vast a group, occurs in Aristotle's history of animals, and denotes sometimes a winged coleopterous insect, at other times a species of crustaceous animal. Latreille supposes it to be a contracted form of *Scarabæus*. In addition to the characters already given, we may mention that the species of the genus, as now restricted, are all of considerable dimensions. Their colours are usually black with a tinge of purple, or greenish with a golden hue. The form of the body is elongated; the head, always narrower than the thorax, is generally of greater extent forwards than transversely, and is borne almost in a horizontal position. The eyes are globular, and behind them the head assumes a narrow neck-like form. The mandibles, which are strong and pointed, are usually destitute of dentation, and may be observed to cross each other when the insect is in a state of repose. The thorax is narrower than the abdomen, is bordered with a slightly recurved margin, and is almost always emarginate in its basal line; its superior portion (strictly speaking the *prothorax*) is more extended than the inferior parts, and covers posteriorly the scutellum of the mesothorax, which, naturally but slightly developed, presents to view its summit only. The elytra are also margined after the manner of the thorax, and their upper surface, rarely smooth, is variously characterized, according to the species, by striæ, furrows, depressed points, or rows of bead-like elevations. The true or membranaceous wings are either wanting or exist in a very rudimentary condition. The species therefore are incapable of flight; but, to make amends for this deficiency, their legs are strong and lengthened, the trochanter is greatly developed, and the tarsi of the anterior pair (in the males) are dilated, with their first four articulations spongy on their inferior face.

All the species are eminently voracious and carnivorous. They not only prey upon the soft bodied and defenceless caterpillars, and on all other insects weaker than themselves, but they even seize upon and devour their own species. They usually avoid strong light, are partial to a certain degree of moisture, and conceal themselves during the heat of the day beneath stones, among mossy herbage, in garden rubbish, or under the stems or within the hollows of fallen trees. We have noted the usual habits of each of the species in the descriptions which follow; and, in regard to their general distribution, we may observe, that their principal seat appears to be the north temperate zone, that they are extremely rare in the warmer regions of the earth, and probably disappear altogether within the tropics. Their larvæ and metamorphoses are but slightly known. Many of the perfect insects exhale a penetrating and fetid odour, and when touched exude a dark-coloured caustic humour.

Mr Stephens enumerates nineteen species of British Carabi. The claims, however, of three or four of these (such as *C. purpurascens, convexus, auronitens*) to be regarded as truly indigenous, are extremely doubtful. The occurrence of an insect on our island shores is sometimes accidental, and results from the fortuitous impulsion of winds or waves. It is well that the visits of these erratic strangers should be recorded, as they afford an interesting illustration of the extreme extent in one direction of their geographical range; but they cannot on that account be considered as "children of the soil." We shall here give a few brief notices of the Scottish species.

C. *catenalatus*, Fab. Oblong-ovate, black, the margins of the thorax and of the elytra violaceous; elytra with interrupted crenated striæ, and three rows of impressed dots, the spaces between the dots slightly elevated. Common throughout Scotland, both on mountains and in plains.

C. *monilis*, Fab. Oblong-ovate, thorax coppery, elytra brassy-green or violaceous, with three series of oblong tubercles, and three equal elevated lines between them. The colour of this species is very variable. It is rare in Scotland, and we have not yet observed it during our excursions to the northern counties.

C. *arvensis*, Fab. Ovate, greenish coppery, or brassy above, elytra with three series of oblong tubercles, and three crenulated lines between them, the central line rather elevated. Not as yet known to be generally spread over Scotland, but collected at several distant points. Pentland Hills, Island of Arran, vicinity of Jedburgh.

C. *cancellatus*, Fab. *C. morbillosus*, Leach. Oblong, metallic green or brassy, elytra with three rows of oblong tubercles, and a single smooth elevated line between them. Not unfrequent in decayed wood and under stones. Neighbourhood of Edinburgh; parish of Durness, Sutherland.

C. *hortensis*, Fab. Ovate, thorax black, margined with purple, elytra brassy brown, with three rows of excavated dots. Common near Edinburgh, occurring in gardens, pathways, &c., during spring and summer, and pretty widely spread over Scotland, but much rarer in the northern counties than *C. catenalatus*, and not partaking with that species in the height of its occasional localities. Only one specimen found in Sutherland among many scores of other species of the genus.

C. *violaceus*, Linn. Elongate, black, the margins of the thorax and of the elytra violaceous; elytra dull black, granulated. An elegantly shaped species, not unfrequent in Scotland, in woods and fields, and among garden rubbish. It also occurs among the mountains, and has been taken at Cape Wrath.

C. *glabratus*, Fab. Oblong, entirely black, the elytra very finely granulated, so as to appear smooth and shining. Inhabits the Pentland Hills, but is very scarce in our southern districts. Not unfrequent among the Grampians and other mountain ranges in the north, where it occurs on the summits of the highest hills. Taken at Cape Wrath, and in other parts of Sutherland.

C. *nitens*, Linn. Ovate, head and thorax golden coppery, elytra brilliant green, margined with coppery-red, and having three blackish ribs on each. Under side of the body, and legs, shining black. This, though one of the smallest, is the most richly adorned of the British Carabi, and is one of the most beautiful of coleopterous insects. It is pretty generally spread over the upland and moorish districts of Scotland. We did not find it in

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[1] *Species Général*, t. ii. p. 33.

[2] *Règne Animal*, t. iv. p. 412.

Sutherland, but we have specimens from the shires of Mid-Lothian, Lanark, Dumbarton, Argyll, Perth, and Forfar. It is always regarded as a valuable acquisition, on account of its extreme beauty.

C. *clathratus.* Oblong-ovate, of a dark brassy hue, thorax rather square, the posterior angles not much produced, the elytra with three elevated lines, and a triple series of deep golden excavations. This is one of the largest and finest of the British Coleoptera. It has hitherto been regarded as a very rare insect, but a closer examination of the wilder districts will probably bring it into more frequent view. We were the first to take it in Scotland,—which we did many years ago, and in considerable numbers (nine or ten specimens in a few days), in the island of Colonsay, the hospitable habitation of John Macneill, Esq. It has been since taken by Mr Macleay in Caithness. Capt. Graham, R. N. and others, also captured several specimens in different parts of Sutherland (near Invershin, on the point of Tongue, and the vicinity of Lairig), in the month of August 1833; and Mr George Little has collected it for some seasons at Ormsary, on the mainland of Argyllshire. On the continent this beautiful insect is found in Siberia, Sweden, Hungary, Italy, and the south of France, especially in the environs of Montpellier. It varies singularly in regard to the development of the true or membranaceous wings. Those which occur in the south of Europe are large, and furnished with wings; those of Sweden and Siberia are apterous, and of smaller size.

GENUS CALOSOMA,[1] Weber, Fab. First four articles of the anterior tarsi dilated in the males; the first three very strongly, the fourth often more slightly. Terminal article of the palpi very slightly securiform. Antennæ filiform; the third article slightly compressed, sharp on the outer edge, and sensibly longer than the others. Labrum bilobed. Mandibles broad, very slightly curved, more or less sharp, transversely striated, without obvious teeth on their interior. A strong tooth on the middle of the emargination of the mentum. Thorax short, almost transversal, more or less rounded. Elytra usually of a square form, more or less elongated, rarely oval or rounded. Wings most frequently fit for flight.

This genus is very widely distributed. There are about thirty species in all, spread in different proportions over Europe, Asia, Africa, and America. *C. sycophanta* (Plate CCXXII. fig. 2) and *inquisitor* have occurred in Britain. The genus is as yet unknown in Scotland.

3d, The third and last division of the *Grandipalpi* of Latreille presents an assemblage of characters which clearly distinguish its component parts from those of the two preceding. Most of the species are winged. The anterior tarsi of the males are always dilated. The labrum is entire. The exterior palpi are merely somewhat dilated or thicker at the extremity, the last joint being in the form of a reversed and elongated cone. The internal side of the mandibles presents no tooth deserving of notice; the one in the middle of the emargination of the mentum is bifid. The centre of the superior margin of the ligula is elevated to a point. On the internal side of the anterior tibiæ of several there is a short emargination, or one of the two spurs is inserted higher than the other, so that in this respect these *Carabici* are somewhat ambiguous, and might be placed, as well as those of the ensuing section, immediately after the *Patellimani.* They usually inhabit moist situations. A few, such as *Omophron,* seem to connect their tribe with that which follows,—the aquatic Carnivora.

In some in which the body is flattened, or convex and suborbicular, the eyes are of ordinary size; the antennæ linear, and generally consisting of elongated and almost cylindrical joints; the external sides of the maxillæ are bearded, and the two internal spines of the two anterior tibiæ are on a level at their origin; these tibiæ have merely a simple longitudinal canal. In LEISTUS, Frœhlich (*Pogonophorus,* Lat.), the exterior palpi are much elongated, the mandibles are dilated at their base, the head is suddenly narrowed behind the eyes, and the antennæ are long and slender. All the species belong to Europe, and the greater proportion are found to occur in Britain. NEBRIA, Lat. resembles *Leistus,* but the palpi are much shorter, the mandibles not dilated, the head not restricted, and the antennæ proportionally thicker, and composed of shorter articulations. Several of the species, such as *N. Gyllenhalii, brevicollis,* &c., are classed by English entomologists in the genus *Helobia* of Leach. In OMOPHRON of Lat. (see Plate CCXXI. fig. 18), the first joint only of the two anterior tarsi is dilated in the males.

In other genera the body is tolerably thick, and the eyes large and prominent; the antennæ are slightly enlarged near the extremity, and composed of short joints, mostly in the form of a top or reversed cone; one of the two spines of the internal extremity of the two anterior tibiæ is inserted higher than the other, with a notch between them. The four or first three joints of the anterior tarsi of the males are in general but slightly dilated. The palpi are more elongated. They occur chiefly by the sides of rivers in Europe and in Siberia. We may here place the genus ELAPHRUS,[2] in which the thorax is convex, rounded, narrowed posteriorly, and nearly of the same length as the head. The elytra are convex and almost parallel. This genus was separated with great propriety by Fabricius from Cicindela of Linn. It is constituted by a few small species, generally distinguished by metallic lustre, and of which one of the most beautiful, *E. lapponicus,* was lately presented to us by Professor Lyell, the learned author of the *Principles of Geology.* It has been hitherto only known as a native of Lapland, and was discovered by Mr Lyell on the north-west side of Catlaw, a mountain in Forfarshire, on a spot nearly 2000 feet above the level of the sea. Several of the smaller species which formerly belonged to *Elaphrus* now form the genus *Notiophilus* of Dumeril. Such are *N. aquaticus, biguttatus,* &c.

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[1] Καλος, *beautiful,* and σωμα, *body.*

[2] Fabricius derives the name from Ελος, *a marsh.* We think it may be more plausibly traced to Ελαφρος, *light, active.*

Synoptical Table of the preceding Section, according to the System of Dejean.

SIMPLICIPEDES.

- Elytra carinated on the sides, and embracing a part of the abdomen. Lateral edges of the thorax
  - scarcely or not at all elevated, and not produced. Anterior tarsi
    - alike in both sexes........ 1. *Cychrus.*
    - dilated in the males........ 2. *Sphæroderus.*
  - much elevated, and produced behind........ 3. *Scaphinotus.*
- Elytra not carinated on the sides, and not embracing the abdomen. Upper lip
  - with two or three lobes. The tooth in the notch of the mentum
    - wanting........ 4. *Pamborus.*
    - simple. Anterior tarsi
      - not dilated in the males........ 5. *Procerus.*
      - dilated in the males. Upper lip
        - trilobed........ 7. *Procrustes.*
        - bilobed. Third joint of the antennæ
          - cylindric, and scarcely longer than the others........ 8. *Carabus.*
          - compressed, sharp exteriorly, and sensibly longer than the others........ 9. *Calosoma.*
  - entire. The tooth in the notch of the mentum
    - wanting........ 11. *Pteroloma.*
    - simple........ 5. *Tefflus.*
    - bifid. Last joint of the palpi
      - scarcely or not at all securiform. Antennæ
        - nodose and elongate. Anterior tarsi dilated in the males,
          - in the three first joints,
            - nearly in a square form, more or less elongate........ 10. *Leistus.*
            - triangular or heart-shaped........ 12. *Nebria.*
          - in the first joint only........ 13. *Omophron.*
        - short and rather thick. Last joint of the palpi
          - elongate and obconic. Anterior tarsi dilated in the males,
            - in the three first joints........ 14. *Pelophila.*
            - in the four first joints. Thorax
              - quadrate, and wider than the head........ 15. *Blethisa.*
              - rounded, and of the same width as the head........ 16. *Elaphrus.*
          - short, and somewhat inflated........ 17. *Notiophilus.*
      - rather strongly securiform........ 18. *Metrius.*

B.

SECTION 7TH, SUBULIPALPI, Lat. Dejean.

These form of themselves the second general division of the Carabici, and are distinguished from the preceding sections by the form of the exterior palpi, of which the penultimate obconical joint is united to the following, forming with it a common oval or fusiform body, terminated either gradually or suddenly in a point, or in the manner of an awl. The two anterior tibiæ have always an emargination on the inner side. The first two articles of the anterior tarsi are alone dilated in the males. This division contains only three genera, as follows:

- Last article of the palpi
  - at least as large as the preceding. Penultimate article of the maxillary palpi
    - as large as the last....1. *Trechus*.
    - smaller than the last..2. *Lachnophorus*.
  - much shorter than the preceding..3. *Bembidium*.

Of the two great tribes, viz. CICINDELETÆ and CARABICI, with the principal genera of which we have just been engaged, there are 2494 species enumerated in the last edition of the Catalogue of Comte Dejean. We come now to

TRIBE 3D, HYDROCANTHARI, Lat.

This tribe is composed of the undivided genera *Dytiscus* and *Gyrinus* of the old writers. Their feet are adapted for swimming; the last four being compressed, ciliated or laminiform, and the last two at a distance from each other. The mandibles are almost entirely covered. The body is always oval, the eyes but slightly prominent, and the thorax much wider than long. The terminal hook of the maxillæ is curved from its base; those at the extremity of the tarsi are often unequal.

All these aquatic Coleoptera pass both their first and final stage of existence in the fresh and placid waters of lakes and marshes, or the undisturbed parts of tranquil rivers, and are distributed over all the countries of the earth, wherever such localities occur, from Greenland to Van Diemen's Land.

The old genus *Dytiscus* (Plate CCXXII. fig. 3 and 4) embraced a vast assemblage of aquatic insects which the more minute observance of modern times has partitioned into many genera. They form a truly amphibious family; for although water is their favourite element, they survive for a long time on moist land, and most of them fly about in the evening and morning twilight, and even during the darkness of the dewy night, with great power and celerity. They vary considerably in size, according to the species, some being extremely small, while others measure between one and two inches in length. They are fierce and voracious in their habits, preying indiscriminately upon whatever smaller and softer tribes they are able to subdue. They are frequently observed resting on the surface of the water, with their legs expanded, their heads downwards, and the terminal segment of their bodies in contact with the air. It is thus that they carry on the process of breathing, for they cannot respire except by bringing a globule of atmospheric air in contact with the stigmata, which are placed on the sides of the abdomen, just beneath the outer margins of the elytra. Being specifically lighter than water, when they feel the necessity of respiration they have nothing to do but to allow themselves to float to the surface, where, by a peculiar action of the tips of the elytra and the terminal segment of the body, a portion of air is brought into contact with the stigmatic openings. The bodies of the larvæ of these insects (Plate CCXXII. fig. 6) consist of eleven well-defined segments. The head is large, flattish, covered above by a scale or shield marked down the centre by a longitudinal furrow. On each side there are five or six black tubercles which are regarded as eyes, and anterior to the eyes are placed the antennæ, consisting of three articulations. The mouth is armed with a pair of strong, horny, curved, sharp-pointed mandibles, which serve to seize and transfix the prey. According to Swammerdam and Degeer, these organs are pierced so as to act as suckers, by means of which the animal juices are absorbed. Near the extremity of the abdomen two delicate appendices may be perceived, pointing obliquely downwards. By means of these the larva appears to suspend itself occasionally from the surface of the water when it wishes to respire. The principal stigmatic openings are at the end of the abdomen, and consist of two small cylindrical bodies, which, when the creature floats, come in contact with the air, and communicate with the tracheal vessels, which are seen to traverse beneath the skin on either side of the body. The movements of these insects in the larva state are effected in the water, partly by the legs and partly by an undulatory motion of the tail. They prey upon other larvæ, such as those of dragon-flies, ephemeræ, gnats, &c. As an instance of their great voracity, it may be mentioned that we once observed one of the larger kinds transfix and suck out the juices of thirteen well-grown tadpoles in a single day. When the period of their transformation has arrived, they leave the water and bury themselves in the moist soft earth of a neighbouring bank. There they work for themselves an egg-shaped chamber, in which they assume the nympha state. (Plate CCXXII. fig. 9.) How long they remain in that condition is not very precisely known, from the difficulty of rearing them in confinement throughout their entire changes, but it is believed that the insect is not long of making its appearance in the perfect state. It may then be kept alive in a tumbler for several seasons, and the larger kinds (*Dytisci* proper) soon assume a certain degree of tameness and familiarity, will follow the finger around the walls of their transparent prison, and, coming to the surface at an accustomed signal, will demand, according to their own mode of expression, a young earthworm, or a piece of fresh beef or mutton; for on these and several other articles they feed from the first with extreme, and as it were accustomed greediness.[1] They may thus be said to be aquatic in the larva state, terrestrial in that of nymph, and amphibious in their winged condition.

GENUS DYTISCUS,[2] Linn. Antennæ setaceous, longer than the head. External palpi filiform, or a little enlarged towards their extremity. Anterior tarsi patelliform in the males, the middle pair with their basal joints dilated; the hind pair long, thick, and tapering to the apex, where there are two very small claws. Plate CCXXII. fig. 3 and 4.[3]

The Dytisci are large aquatic beetles, the characteristic habits of which have been sketched in our preceding general observations. We are acquainted with about fourteen species, six or seven of which inhabit Britain.

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[1] Esper kept a living specimen of *Dytiscus marginalis* in a glass vessel for three years and a half. It fed on beef.

[2] From δυτης, *a diver.*

[3] Figure 5 of the plate above referred to represents the head of *D. serricornis*, a species remarkable for the anomalous form of the antennæ. (See *Nov. Act. Acad. Scient. Stockh.* xx. 1, 3.)

D. *punctulatus* seems to be the most common in Scotland. It thrives well in confinement, and will live for a year or two in any small vessel, feeding on earthworms and shreds of beef or mutton.[1] *D. marginalis*, when recently captured, has a smell resembling liquorice. It is said to kill Hydrus piceus, which is a much larger and apparently stronger insect, by piercing it between the head and thorax, the only part of the body which is unprotected. Esper asserts that it is much affected by atmospheric changes, and that it indicates these, when in a state of confinement, by the height at which it remains in its jar.

In the genus Colymbetes[2] of Clairville (fore leg, Plate CCXXII. fig. 7), the four anterior tarsi have their three first joints equally dilated in the males, and forming collectively a small pallet in the form of a lengthened square. The antennæ are at least as long as the head and thorax. The eyes are slightly or not at all projecting. Many of these insects are common in ditches and small brooks, and their habits resemble those of the preceding genus. There are about seventy species in all, of which one half inhabit Britain.

The genus Acilius was first proposed by Dr Leach in the *Zoological Miscellany*. It is distinguished by the great flatness of the species; by the hairy elytra of the females, which have but few striæ; and by the basal joint of the tarsi in the second pair of legs not being dilated.

In the genus Hygrobia[3] of Lat. the antennæ are shorter than the head and thorax, the body is ovoid, and very thick in the middle, and the eyes are prominent. (Plate CCXXII. fig. 11.)

In Hydroporus[4] of Clairville, the four anterior tarsi are nearly similar, and spongy underneath, in both sexes, and are composed apparently of only four joints, the fifth being deficient, or very small, and concealed along with a portion of the fourth in a cleft of the third articulation. The scutellum is not apparent.[5] In Noterus[6] of the same author, the antennæ are slightly dilated in the middle, and the last joint of the labial palpi is emarginate, and appears forked. In Haliplus,[7] Lat. there are only ten distinct joints in the antennæ; the external palpi are fusiform, or have a more slender termination, tapering to a point; the body is convex and ovoid beneath; all the tarsi are filiform, composed of five cylindrical joints, and have nearly the same form in both sexes.

All the preceding genera of *Hydrocanthari* belonged to the old genus *Dytiscus*. The remainder of the tribe are comprised in the

Genus Gyrinus,[8] Linn. Antennæ shorter than the head, the basal joint very large, and produced externally into a triangular ciliated lobe, the rest forming a clavate mass, attached by a short peduncle to the upper side of the first joint. Anterior legs rather long, and projecting like arms; the others compressed, ciliated, and formed for swimming. (Plate CCXXII. figs. 8 and 12.)

In this genus the body is oval and generally very glossy. The head is sunk in the thorax almost to the eyes, and these are large, and divided by a horny process or border, in such a way that there seems to be two above and two below. Only seven joints of the terminal portion of the antennæ are distinctly visible. The singular auriform shape of these organs induced Latreille to form the Gyrini into a family along with *Parnus*, under the name of *Otiophori*. But at an after period that great entomologist approximated the genus to the *Dytiscidæ*, thereby correcting the error he had previously committed of confounding, as Mr Macleay observes, a relation of analogy with one of affinity. The Gyrinidæ live in society, and several species are extremely common on our ponds, and ditches by the way side. They swim flat upon the surface, with their shining backs above water, chasing each other in circles, or darting about in more irregular gyrations. When hemmed into a corner of the pond, they make their escape by darting beneath the surface, carrying along with them a portion of air, which shines like quicksilver. Britain produces several species of this genus. They are known in England by the name of whirlgigs. These insects fly well, and transport themselves with ease and rapidity from place to place. The females deposit their eggs on the leaves of aquatic plants. The eggs are very small, lengthened in the form of little cylinders, and of a white colour tinged with yellow. According to the observations of Degeer, they produced minute six-footed larvæ in the course of eight days, which swam in the water, or crept along the sides of the vessel in which they had been deposited. Neither he nor Roesel, however, could succeed in rearing them to a state of completion. These larvæ (Plate CCXXII. fig. 17) exhibit rather a singular aspect, and at first sight resemble small Scolopendræ. They are of a dingy white or greyish colour, and their clear transparent skin permits the view of their internal structure. Their bodies are long, slender, cylindrical, and divided into thirteen rings, which are deeply incised. The head is oval, very much elongated, and flattened both above and below. It is armed in front with a pair of comparatively large curved jaws, tipped with brown, which, when closed, meet with their points in advance of the head, but are capable of wide extension. The structure of these parts demonstrates a carnivorous disposition. The antennæ are very delicate, divided into four articulations, and equal the head in length. The first segment of the body is nearly twice as long as the others, and the three pairs of feet are attached to the first three segments. The eight following rings are garnished with very singular, long, slender, transparent filaments, which float in the water without being apparently under the guidance of the animal. From their resemblance to the gills of the Phryganeæ and Ephemeræ, it is probable that these are the respiratory organs. The twelfth or penultimate segment of the body is furnished with four of these filaments, of much greater length than the preceding, and covered with long hairs or secondary filaments. The last segment, which is much less than the others, is terminated by four long and remarkable hooks, placed parallel to each other, with their points bent beneath inwards. The whole body seems filled with little globules of air, which are in frequent motion, sometimes towards the head and sometimes towards the other extremity. Modeer has described the transformations of these creatures in the Memoirs of the Royal Academy of Sweden. About the beginning of August, according to that author, the larvæ leave the water, and, crawling up the stems of reeds or other aquatic plants, they are transformed into nymphs, beneath the envelope of a small cocoon, pointed at both ends, and formed of a substance resembling grey paper. Towards the end of the same month the perfect insect is

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[1] *Entomologia Edinensis*, p. 127.

[2] From κολυμβαω, *to swim.*

[3] From ὑγρὸς, *moist*, and βιος, *life.*

[4] From ὕδωρ, *water*, and πορος, *a passage.*

[5] For the other genera, see the works of Messrs Stephens and Curtis. The Scotch species are described by Messrs Wilson and Duncan in the *Entomologia Edinensis.*

[6] From νοτερος, *humid.*

[7] From ἅλς, *the sea*, and πλοος, *sailing.*

[8] From γυραω, *to go in a circle.*

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excluded, and immediately jumps into the water. Modeer adds, that the cocoons are very frequently found pierced by the ovipositor of an ichneumon fly.

Great Britain produces nine species of the genus *Gyrinus* (including *G. villosus*, which belongs to *Potamobius*, Leach[1]). There are twenty-six in all. They are rare in Africa and Asia, but are widely spread over Europe, North and South America, and New Holland. We have received a large species from Java. They are also found at the Cape and the Isle of France.

The most common and best-known species in this country is *G. natator*, of an oval form, bluish-black, extremely glossy, the inflected margin of the elytra, apical segments of the abdomen, and legs, ferruginous. This agile little creature appears to have been rather a favourite object of observation with the entomologist. "Water, quiet still water," says Mr Knapp, "affords a place of action to a very amusing little fellow (*Gyrinus natator*), which, about the month of April, if the weather be tolerably mild, we see gamboling upon the surface of the sheltered pool; and every schoolboy who has angled for minnows in the brook is well acquainted with the merry swimmer in his shining black jacket. Retiring in the autumn, and reposing all the winter in the mud at the bottom of the pond, it awakens in the spring, rises to the surface, and commences its sports. They associate in small parties of ten or a dozen near the bank, where some little projection forms a bay, or renders the water particularly tranquil; and here they will circle round each other, without contention, each in his sphere, and with no apparent object, from morning until night, with great sprightliness and animation; and so lightly do they move on the fluid, as to form only some faint and transient circles on its surface. Very fond of society, we seldom see them alone, or, if parted by accident, they soon rejoin their busy companions. One pool commonly affords space for the amusement of several parties, yet they do not unite or contend, but perform their cheerful circlings in separate family associations. If we interfere with their merriment they seem greatly alarmed, disperse or dive to the bottom, where their fears shortly subside, as we soon again see our little merry friends gamboling as before. This plain, tiny, gliding water-flea seems a very unlikely creature to arrest our young attention; but the boy with his angle has not often much to engage his notice; and the social active parties of this nimble swimmer, presenting themselves at these periods of vacancy, become insensibly familiar to his sight, and by many of us are not observed in after-life without recalling former hours—scenes of perhaps less anxious days; for trifles like these, by reason of some association, are often remembered when things of greater moment pass off and leave no trace upon the mind."[2] Wordsworth has likened a beetle to

> A mailed angel on a battle day;

and Messrs Kirby and Spence describe the subjects of our present notice as being "covered with lucid armour,—when the sun shines they look like little dancing masses of silver and brilliant pearl."[3] They however exhale a disagreeable and rancid odour.[4]

FAMILY II.—BRACHELYTRA, LAT.[5]

In this, the second family of Pentamerous Coleoptera, Latreille places those genera which have only a single palpus to each maxilla, or four in all, including the labial pair. The antennæ, sometimes of equal thickness, and at others slightly enlarged at the extremity, are usually composed of lenticular or graniform articulations; the elytra are much shorter than the body (from which circumstance they derive their name), and the latter is narrow, elongated, generally depressed, with the coxæ of the two anterior legs very large. The posterior extremity of the body is provided with two vesicles, which are protruded at will.

These Coleoptera composed the great genus *Staphylinus* (of Linnæus) before its subdivision by more recent writers. Ancient authors appear to have bestowed the name of *Staphylinus* on certain species, which, from the characters assigned them, and their reputed injurious effects on horses, we can scarcely refer to any of the modern genera of brachelytrous insects. Mouffet, however, having satisfied himself that some ancient passage did apply with sufficient correctness, made use of the term Staphylinus in relation to the present group; and whatever may have been its original application, its meaning is now no longer ambiguous in the modern systems. The genus, as constituted by Linnæus, was first dismembered by Fabricius of two of its component groups, under the generic names of *Pæderus* and *Oxyporus;* and in still more recent times numerous other subdivisions have taken place, which have raised the original genus to the rank of an ordinal section or comprehensive family.

Some writers regard the Staphylini as forming the passage from the Coleoptera in general to the Forficulæ or ear-wigs, which compose the first genus of the *orthopterous* order. In their habits they somewhat resemble the Silphæ and Necrophori. They have usually a large, flattened head, strong mandibles, short antennæ, and a thorax as wide as the abdomen, which is long, narrow, and generally depressed. The elytra are very short and truncated, although they still suffice to cover the long membranous wings, which, when not in use, are compactly folded. The upper portion of the segments of the abdomen, being exposed in consequence of the shortness of the elytra, is, contrary to the usual rule among the coleopterous tribes, of as firm a consistence as that beneath. From the terminal segment of the abdomen two vesicles are protruded or retracted at the pleasure of the animal, and from these, when irritated, a subtile vapour makes its escape with a strong odour of sulphuric ether. "Though most of the micropterous species," Mr Kirby observes, "have a fetid smell, yet there are some exceptions to this amongst them. One species (*S. suaveolens*, K. MS.), related to *S. micans*, Grav. which I once took, smelt precisely like a fine high-scented ripe pear; another, *Oxytelus morsitans*, like the water-lily; a third, *O. rugosus*, like water-cresses; and lastly, a fourth (*S. fuscipes*) like saffron." M. Leon Dufour has described the apparatus by which these odours are produced.[6] The insects of this family, when attacked or touched, elevate the extremity of their abdomen, bend it in various directions, and frequently protrude the vesicles above alluded to. They also use the point of the abdomen to close or unfold their wings. The tarsi of the two anterior legs are frequently broad and dilated, and their coxæ, as well as those of the intermediate pair, are very large. The species usually occur in damp places, under stones, in earth, and excrementitious matters. Some live in mushrooms and fungi, or in rotten wood, while a few of the smaller species are found on flowers. They are all swift, active, and voracious.

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[1] *Orectochilus* of Eschscholtz and Dejean.

[2] *Journal of a Naturalist*, p. 307.

[3] *Introduc. to Ent.* vol. ii. p. 372.

[4] For the Scottish species, see *Entomologia Edinensis*, p. 130.

[5] From βϱαχὺς, *short*, and ἐλυτϱον, *sheath.* MICROPTERA, Gravenhorst. STAPHYLINUS, Linn.

[6] *Ann. des Sciences Nat.* t. viii. p. 16.

The larvæ bear a close resemblance to the perfect insect. In figure they more nearly resemble an elongated cone, the base of which is formed by the head; the terminal segment is prolonged into a tube, and is accompanied by two conical and hairy appendages. Their food and habits of life are very similar to those of the imago.

According to M. Dufour, the only essential difference between the alimentary canal of the brachelytrous tribes and that of the carnivorous Coleoptera consists in the absence of the crop. The first stomach is small and destitute of folds; the second is very long and pilose; the intestine is extremely short. The biliary vessels are inserted at the same lateral point as in the Carnivora, and present in some species, near the middle, a knot or vesicle, not observable in any other insects. Their sexual apparatus differs greatly from that of the carnivorous Coleoptera.[1]

Many of the species of this family are of minute dimensions, and a knowledge of their names and characters is of difficult attainment. Many more of the described species than have been hitherto collected no doubt exist in Britain, and many of the Scandinavian species will probably be discovered to inhabit Scotland. There is every reason, indeed, to believe that an assiduous entomologist would here reap a rich harvest among a tribe of insects which seem characteristic of, though by no means peculiar to, temperate or northern countries. Notwithstanding the obscurity in which many of our smaller species are still involved, Great Britain already possesses nearly *eight hundred* recorded species of brachelytrous insects, while the last edition of Dejean's Catalogue (1833), including European and exotic kinds, gives only 789.[2]

In a family so extensive, and of late so minutely subdivided, we must satisfy ourselves with a few brief indications of the principal genera. It is divided into five great sections.

1*st*, FISSILABRA.

In these the head is completely exposed, and separated from the thorax (which is sometimes square or semi-oval, sometimes rounded or cordiform, and truncated) by a neck or sensible restriction. The labrum is deeply bilobed.

In OXYPORUS,[3] Fab. (Plate CCXXII. fig. 13), the maxillary palpi are filiform, those of the labium terminated by a large and lunate article. The antennæ are large, perfoliate, and compressed. The anterior tarsi, of which the last (and next to it the second) joint is the longest, are not dilated. The species inhabit *Boleti* and *Agarici*. In ASTRAPÆUS, Grav. the four palpi are terminated by a larger and nearly triangular article. The anterior tarsi are greatly dilated, and the first and last joints are the longest. In STAPHYLINUS, Fab. (the true *Staphylini*), all the palpi are filiform, and the antennæ are inserted between the eyes, above the labrum and mandibles. Some, particularly the males, have the anterior tarsi greatly dilated, and the antennæ rather distant at the base; the length of the first joint being equal at most to that of a fourth of the whole number. The head is but slightly elongated. These, according to the views of some authors, alone constitute the genus.[4] Our largest British species, *S. Olens* (*Goerius*, Leach), is placed here by Latreille, along with a more ornamental example, *S. erythropterus* (Plate CCXXII. fig. 16). Others are linear, with the head and thorax in the form of an elongated square, and the antennæ approximated at the base, and strongly geniculate and granose. The anterior tarsi are either not at all or but slightly dilated. The anterior tibiæ are spinous, with a stout spine at the extremity. The labrum is small. These form the genus *Xantholinus* of some authors. In PINOPHILUS of Grav. the palpi are filiform, but the antennæ are inserted before the eyes, outside the labrum, and near the exterior base of the mandibles. In LATHROBIUM (Plate CCXXII. fig. 21) of the same author (*Pæderus*, Fab.), the palpi are terminated suddenly by a pointed and often indistinct article, much smaller than the preceding; those of the maxillæ are longer than the labial; the antennæ are inserted as in *Pinophilus;* the anterior tarsi are strongly dilated in both sexes; and the length of the last joint of the four posterior tarsi is almost equal to that of the four preceding taken together.

2*d*, LONGIPALPI.

In this section the head is also completely exposed, but the labrum is entire, the maxillary palpi nearly as long as the head, with a clavate termination formed by the third joint, the fourth concealed or but slightly visible, and, when apparent, terminating the club in the form of a small point; the preceding much enlarged. These insects dwell chiefly along the shores of rivers, or on banks in the vicinity of water.

In PÆDERUS, Fab. (Plate CCXXII. fig. 15), the antennæ, inserted before the eyes, are filiform, or gradually increase in thickness. In EVÆSTHETUS of Grav. the antennæ are likewise inserted before the eyes, but are hardly longer than the head, and almost entirely moniliform; the body is but slightly elongated, and the head as wide as the thorax. In STENUS,[5] of Lat. (Plate CCXXII. fig. 20), the antennæ are inserted near the margin of the eyes, and are terminated by a triarticulated club. The extremity of the mandibles is forked. The eyes are large.

3*d*, DENTICRURA, Lat.

This section differs from the preceding in the form of the maxillary palpi, which are much shorter than the head, and always consist of four distinct articles; the anterior tibiæ, at least, are dentated or spinous along their exterior side. The last joint of the tarsi, which in most are bent under the tibiæ, is as long as all the preceding joints combined, or longer; and the first or first two are usually so small or so concealed that their total number does not seem to exceed two or three. In several males the forepart of the head, and even the thorax, is armed with horns. The antennæ are inserted before the eyes. With the exception of the *Tachini*, the anterior tarsi are no longer dilated.

In OXYTELUS, Grav. the palpi have an awl-like termination, the antennæ are mostly granose, and gradually enlarged towards the extremity. The tarsi present only

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[1] *Ann. des Sciences Nat.;* and *Règne Animal*, p. 432.

[2] Mr Stephens arranges his British *Brachelytra* in five families, containing eighty-two genera. How vague, from its extremely comprehensive limits, must have been the original *genus* Staphylinus of Linn., when even our indigenous species present the groundwork of such diversified groups! Perhaps, however, we may be now falling into the opposite extreme.

[3] From ὀξύπορος, *that crosses swiftly.*

[4] *S. dilatatus*, Fab. has been separated from the above on account of its antennæ, which form an elongated serrated club. It is said to feed on caterpillars, which it searches for on trees.

[5] From στενος, *narrow.*

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three distinct articles. In **Ozorius**, Leach, the body is cylindrical, all the tibiæ broadened and dentated, the head as long as it is wide, the thorax almost cordiform. The mentum is large and buckler-shaped. The species come from America and Madagascar. In **Coprophilus**,[1] Lat., the body is flattened, and the antennæ much longer than the head.

4*th*, Depressa, Lat.

In these the head is disengaged or free, as in the preceding, the labrum entire, the maxillary palpi short, and of four articulations; but the tibiæ are simple, or without teeth or exterior spines, and the tarsi exhibit five obvious articulations.

In the two following genera the palpi are filiform. **Omalium**, Grav. Thorax as wide as the elytra, wider than the head, and almost forming a transverse square; the angles, at least the anterior ones, rounded, and frequently exhibiting a raised lateral margin; the antennæ enlarging towards their extremity. **Lesteva**, Lat., *Anthophagus*, Grav. (Plate CCXXII. fig. 22.) Thorax cordiform, narrowed, truncated posteriorly, almost isometrical, as wide as the head, and narrower than the elytra. In the ensuing genera the palpi are subulate. **Micropeplus**,[2] Lat. (Plate CCXXII. figs. 10 and 14.) Antennæ terminating in a solid club, and lodged in fossulæ of the thorax. **Proteinus**, Lat. Antennæ granose, somewhat perfoliate, and larger at the end, but clavate, always exposed, and inserted before the eyes; the thorax is short, and the elytra cover the whole of the abdomen. **Aleochara**, Grav. Antennæ inserted between the eyes, or near their inferior margin, and exposed at the base, with the first three joints obviously longer than the following ones, which are perfoliate, the last elongated and conical; the thorax is nearly oval, or like a square rounded at the angles.

5*th*, Microcephala, Lat.

Head sunk posteriorly into the thorax, nearly up to the eyes, and separated neither by a neck nor visible restriction; the thorax is in the form of a trapezium, and is widened from before backwards. The body is less elongated than in the preceding section, and approaches more to an ellipsis; the head is much narrower, contracted, and projecting forwards, and the mandibles are of moderate size, edentated, and simply curved at the point. The elytra in several cover rather more than the half of the upper surface of the abdomen. Some of the species live on flowers and mushrooms, others on dung.

In **Lomechusa**, Lat., the tibiæ have no spines; the antennæ from the fourth joint form a perfoliaceous club, elongated or fusiform; the palpi are subulate; the antennæ frequently shorter than the head and thorax. In **Tachinus**,[3] Grav. (Plate CCXXII. fig. 23), the tibiæ are spinous, the antennæ composed of pyriform joints, and insensibly enlarging; the palpi are filiform. **Tachyporus**[4] of Grav. (Plate CCXXII. fig. 28) resembles the preceding in the tibiæ and antennæ; but the termination of the palpi is subulate.[5]

FAMILY III.—SERRICORNES, Lat.

In this family of pentamerous Coleoptera, we find only four palpi, as in the preceding family, and those that follow. The elytra cover the abdomen, which character, with certain others, distinguishes the **Serricornes** from the **Brachelytra**.[6] The antennæ, with some exceptions, are equal throughout, or smaller at the extremity, dentated either like a saw or comb, or even fan-like; and in that respect are more developed in the males. The terminal article of the tarsi is often bilobed or bifid. These characters are rarely visible in the ensuing family, that of **Clavicornes**; at which, however, we shall arrive by transition so graduated, that rigorous limits are with difficulty assigned.

Section 1st, Sternoxi,[7] Lat.

Body always of a firm and solid consistence, and generally of an oval or elliptical form; the feet in part contractile; the head sunk vertically into the thorax up to the eyes; and the præsternum or median portion of the thorax elongated, dilated, or advanced as far as beneath the mouth, and usually marked on each side by a groove, in which the antennæ, always short, are lodged, and prolonged posteriorly to a point, which is received by a depression of the anterior extremity of the mesosternum. The anterior legs are distant from the anterior extremity of the thorax. This section is further divisible into two tribes.

Tribe 1st, Buprestides.

In these the posterior projection of the præsternum is flattened, not terminated in a laterally compressed point, and simply received into a depression or emargination of the mesosternum. The mandibles are frequently terminated in an entire point, without fissure or emargination. The posterior angles of the thorax are either not at all or but slightly prolonged. The terminal article of the palpi is generally almost cylindrical, scarcely thicker than the preceding; the others globular or ovoid. Most of the articulations of the tarsi are generally broad or dilated, and furnished with pellets beneath. These insects never leap, a character which distinguishes them decidedly from the *Elaterides*. This tribe corresponds to the old *genus Buprestis*, as constituted by Linnæus,—the *Richard* of Geoffroy;[8] so named by the latter author on account of the extreme richness of their external covering. Even of the European species several are extremely beautiful, and many of the foreign kinds are not only of the largest size for the class of insects, but present a brilliant surface, beset as it were with gold and emeralds, or glittering with an iridescent play of green and azure. The body is in general oval, somewhat lengthened, rather wider and obtuse before, as if truncated, and narrowed behind from the base of the abdomen. The eyes are oval, the thorax short and wide. The scutellum small or unapparent. The extremity of the elytra is frequently dentated. The legs are short.

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[1] From κοπρος, *dung*, and φιλος, *a lover*.

[2] From μικρος, *small*, and πεπλος, *a covering;* the elytra being so short as to leave a considerable part of the abdomen exposed. This genus is placed in the necrophagous family, *Nitidulidæ*, by Mr Stephens.

[3] From Ταχινος, *swift, active*.

[4] From Ταχυς, *quick*, and πορος, *a passage*.

[5] For the species of this family, see Gravenhorst's *Coleoptera Microptera*, Gyllenhal's *Insecta Succica*, &c. With Mr Duncan's aid, we have described the genera and species of ordinary occurrence near Edinburgh (*Ent. Ed.* pp. 308–388); but, as already mentioned, numerous undescribed *Brachelytra* inhabit Scotland.

[6] In the genus *Atractocerus*, however, the elytra are extremely short. In Proteinus of the preceding family they are, on the other hand, comparatively long; thus showing the tendency to exception in each general rule.

[7] From Στερνον, *sternum*, and οξυς, *pointed*.

[8] "This genus," it has been observed, "furnishes the most beautiful coleopterous insects which can adorn either the domain of nature or the cabinet of the naturalist. Most part of the species are clothed with such brilliant colours, that Geoffroy has thought proper to designate them all under the generic appellation of *Richard*. The origin of this name is as singular as its application is fantastical. It was originally given to the jay, in consequence of the facility with which that bird was taught to pronounce the word." (Griffith's *Animal Kingdom*, *Insecta*, part 2d, p. 356.) Professor Klug has stated that the Berlin Museum possesses not less than five hundred species of the Linnæan genus Buprestis.

All these insects walk very slowly, but fly exceedingly well in dry and sultry weather. When an attempt is made to seize them they drop upon the ground, with a view no doubt to conceal themselves in the subjacent herbage. The abdomen of the female is furnished at its extremity with a coriaceous or horny conical appendage, composed of three pieces (the terminal abdominal rings), and which may be regarded as a kind of ovipositor, by which she deposits her eggs in dry or decayed wood, in which the larvæ dwell. Several of the minor species occur on leaves and flowers; but the greater proportion are found in forests or depots of timber. They sometimes appear suddenly in places where they were never seen before, having been involuntarily transported in foreign timber in the nymph or larva state.

The *Buprestides* are very common in South America and many of the other sultry regions of the earth. They decrease in number as we advance northwards into the temperate climes, and altogether disappear in colder countries. Scarcely a score occur in Britain; and of these we are not aware that even one has yet been found in Scotland.

Genus Buprestis,[1] Lin. Palpi filiform, or slightly enlarged towards the extremity, terminated by an almost cylindrical article. Antennæ of equal thickness throughout, and serrated from the third or fourth joint. Penultimate article of the tarsi deeply notched. Maxillæ bilobed.

These are the characters of the genus Buprestis, as restricted in recent times. Some of the species have no apparent scutellum. Such is *B. fasciculata*, a species from the Cape of Good Hope. It is about an inch long, of a golden or coppery-green, densely punctured, and with little tufts of yellowish or reddish hairs. It sometimes hangs in such abundance on a shrub, as to make it appear all laden with flowers. Others are furnished with a scutellum. Of these we may name *B. gigas* from Cayenne, a species, as its name implies, of the largest size; the thorax cupreous, mingled with brilliant green, and two large spots like burnished steel; the elytra tridentate at the end, cupreous in the centre, bronze-green on the margin, with impressed points and some elevated lines and ridges. Its larva is represented on Plate CCXXII. fig. 19. On the same plate (fig. 18) we have delineated a magnificent species, *B. bicolor*, lately received from Java. It is of a deep-green colour, with a golden lustre, two cream-coloured spots on the elytra, and one on each side of the thorax. It belongs to the genus Catoxantha of Dejean.

Of the other genera of the tribe we shall here name only Trachys, Fab. (Plate CCXXII. fig. 26), Aphanisticus, Lat., and Melasis, Oliv.[2] The last-mentioned genus (probably named from *μελας, black*), conducts naturally to

Tribe 2d, Elaterides.

This numerous tribe corresponds to the undivided genus *Elater* of Linnæus, and differs from the *Buprestides* chiefly in the posterior style of the præsternum, which is prolonged to a sharpish point or spine laterally compressed. On examining the living species, the use of the last-named organ becomes obvious. The legs are very short, and when the creature falls upon its back, which it frequently does while dropping from a plant to the ground, it can only assume its natural position by springing upwards, which it is enabled to do by bringing the projecting point into sudden contact with a groove situated in front of the mesosternum. The sides of the præsternum are also distinguished by a groove, in which the antennæ, pectinated or bearded in several males, are partly lodged. The females have a species of elongated ovipositor, with two lateral pieces pointed at the end, between which is the true oviduct. The tarsi are entire.

The Elaterides occur in flowers, on various plants, and on the ground. We owe to Degeer the description of the larva of one species (*undulatus*). It is long, nearly cylindrical, provided with small antennæ, palpi, and six feet. Its body consisted of twelve scaly segments, of which the posterior was covered by a circular plate, furnished with two blunt points curving inwards; underneath was a large fleshy mammilla, which seemed to serve the office of a foot. The larvæ of *Elater striatus* are said to do much injury, by attacking the roots of wheat. The grub known in this country under the name of wire-worm is an Elater in the early state. It lives under ground for several years, feeding on the roots of grain and vegetables. It is partial to land newly broken up, and does great damage in gardens recently converted from pasture-land. In the year 1813, according to Mr Spence, this larva destroyed the greater proportion of the annuals sown in the botanic garden of Hull. In such cases Sir Joseph Banks recommended that slices of potatoes stuck upon skewers should be buried near the seeds, and examined and cleared of the wire-worms from time to time.

M. Leon Dufour has studied the anatomical structure of several species of this family. In the number, length, and mode of insertion of the hepatic conduits, they show a resemblance to the Carabidæ. The digestive canal is seldom more than once and a half the length of the body. Immediately succeeding an œsophagus, so short as to be included within the region of the head, there is a small smooth conical crop, which appears to have escaped the observation of Ramdhor. The chylific ventricle is bilobed in certain species. This tribe is very extensive both in exotic and European species, and is much more prevalent in temperate and even northern countries than the preceding. The *Elaterides* now consist of numerous genera. Some of the American species are remarkable for the fine phosphoric light which is observed to emanate from them during the evening twilight, and when the shades of night have fallen upon the forests. One of these had the fortune to be transported to Paris under the form of nymph or larva; and having made its escape into the streets after the assumption of the perfect state, it greatly astonished the inhabitants of the Faubourg St Antoine. Most of the genera are recognisable, in a general way, by their narrow, elongated, and somewhat flattish forms. We have above sixty species in Britain, arranged according to the modern views, under not less than twenty genera.

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[1] From Βους, *an ox*, and πρηστης, *swelling*, in allusion to the supposed injury produced on cattle by an insect anciently named *Buprestis.*

[2] For the species, the reader may consult Olivier, *Coléoptères*, t. ii.; Fabricius, *Systema Eleut.* t. ii.; and Schœnherr's *Synonymia Insectorum.* See also *Règne Animal*, t. iv. p. 446.

The various groups of the *Elaterides* are referred by Latreille to two principal divisions.

1st, Antennæ entirely received into the inferior cavities of the thorax.

In some the antennæ are received on each side into a longitudinal groove, placed directly under the lateral edges of the thorax, and are always filiform, and simply serrated. The joints of the tarsi are always entire, without prolongations, and in the form of a pellet underneath. The thorax is convex or arched, at least on the sides, and dilates towards the posterior angles in the manner of a lobe, pointed or triangular. They approach the *Buprestides.* Here are placed the genera GALBA and EUCNEMIS.

In others the antennæ, sometimes clavate, are received, at least partially, either into the longitudinal grooves of the lateral borders of the præsternum, or into fossettes placed under the posterior angles of the thorax. The tarsi are frequently provided with little pellets, formed by the prolongation of the inferior parts, or the penultimate article is bifid. Here are placed the genus ADOLECERA, Lat. (Plate CCXXII. fig. 29), and others.

2d, Antennæ exterior or exposed.

In the genus CEROPHYTUM, Lat. (Plate CCXXII. fig. 30), the terminal joint of the palpi, especially the maxillary, is much larger than the preceding, and almost securiform. These insects are more particularly distinguished from the following by their tarsi, of which the first four articles are short, triangular, with the penultimate bifid. The antennæ of the males are ramose on the internal side, the base of the third and following articles being prolonged into a widened branch, rounded at the extremity; those of the female are serrated. In the succeeding genera the articles of the tarsi are entire and almost cylindrical. In HEMIRHIPUS, Lat. (Plate CCXXII. fig. 31), the mandibles and labrum are exposed, and the antennæ of the male have a flabelliform termination. The species are foreign to Europe. In ELATER properly so called (Plate CCXXII. fig. 27), the antennæ of the males are simply serrated. Here we place the fire-fly, or *mouche lumineuse* of the French colonists, which during the night diffuses from its thoracic spots a strong and beautiful light, sufficient to enable one to read the smallest print, particularly if several are placed together in a glass vessel. By means of this natural illumination the women of the country (the species is South American) are said to pursue their work, and ladies even use it as an ornament, placing it among their tresses during their evening promenades.[1] M. de la Cordaire, who has studied the habits of these insects in the living state, informed M. Latreille that the principal reservoir of phosphoric matter is placed below, at the junction of the thorax and abdomen.[2] Mr Curtis had the insect alive in London, and has recorded his observations with his accustomed accuracy.[3] In the genus CTENICERA,[4] Lat. the antennæ of the males are pectinated.[5]

We shall conclude by observing that the name of *wire-worm*, bestowed on several larvæ of Elaters, is more specially applicable to the early state of *Cataphagus lineatus*[6] of Stephens. Its history appears to be given in the *Stockholm Transactions* for 1777, by Mr Bierkander. He calls it the *root-worm.* It measures when full grown about seven lines in length. The body is very narrow, of a yellow colour, hard, shining, and composed of twelve segments, on the last of which are two indented dark-coloured specks. The head is brown, the extremity of the jaws black. The anterior segments have six scaly feet. It is said to remain five years in the larva state, from which it issues as an Elater, the *E. segetis* of Bierk. supposed to be synonymous with the *E. lineatus* of Linn. and the insect above named of Stephens. Great damage is often occasioned by the wire-worm to the turnip crops. An instance is recorded by Messrs Kirby and Spence of a field in which it had destroyed one fourth of the crop, and the owner calculated his loss at L.100. He one year sowed a field thrice with turnips, which were twice wholly, and the third time in great part, cut off by this destructive larva.[7]

SECTION 2D, MALACODERMI.[8]

The insects of this section are distinguished from the *Sternoxi* by their bodies being generally, in whole or in part, of a soft or flexible texture. From this character they derive their name. Their head is likewise inclosed posteriorly in the thorax, or at least covered by it at the base; but the præsternum is not dilated or advanced anteriorly in the manner of a chin-cloth (*mentonnière*, Lat.), nor is it usually terminated posteriorly in a point received into a cavity of the mesosternum.[9] The Malacodermi are divided into five tribes.

TRIBE 1ST, CEBRIONITES.

So named from the genus *Cebrio* of Fabricius, with which all the others are connected. The mandibles terminate in a simple or entire point, the palpi are of equal thickness, or more slender towards the extremity. The body is rounded or convex in some, oval or oblong, but curved above, and inclined anteriorly, in others. The thorax is transversal, broader at the base, with the lateral angles sharp, or even prolonged, in many, in the form of a spine. The antennæ are generally longer than the head and thorax. The legs are not contractile. The habits of these insects are unknown. Many are found on plants, in moist places.

In CEBRIO (proper)[10] of Lat. the præsternum terminates posteriorly in a point, received by a groove of the mesosternum. All the joints of the tarsi are entire and without pellets, and the posterior thighs are not larger than the others. The species peculiar to Europe appear in great numbers after heavy rains. Of the ten species enumerated by Dejean, seven occur in Europe, one in Africa, one in Java, and one in North America. In CALLIRHIPIS, Lat. (Plate CCXXII. figs. 32 and 33), the præsternum is not prolonged into a point, the antennæ are closely approximated at the base, inserted on an eminence, and from the third joint, in the males, form a large fan. The terminal joint of the palpi is ovoid, that of the tarsi almost as long as the others united, and presenting between its hooks a little silky and linear appendage. We have represented the head of the species (*C. Dejeanii*), which serves as the type of the genus. It occurs in Java. In RHIPICERA[1] of Lat. and Kirby[2] (Plate CCXXIII. fig. 1), the inferior surface of each of the first four joints of the tarsi presents two membranous and projecting lobes; the last is long. The antennæ are flabelliform in both sexes, and consist of much more than the ordinary number of eleven joints. The articulations are much fewer in those of the females. The genus consists of a few species from North and South America and New Holland. In DASCILLUS, Lat. (*Atopa* of Fab.), the antennæ are simple in both sexes, the first three joints of the tarsi reversed cordiform, without membranous prolongations; the penultimate is deeply bilobed. *D. cervinus* (Curtis, B. E. V. pl. 216), the only British species, occurs rather plentifully in the alpine districts of Scotland. In the remaining Cebrionites the mandibles are small, and project but little, if at all, beyond the labrum. The body is generally soft, and almost hemispherical or ovoid, and the palpi terminate in a point. The posterior legs of several are fitted for leaping. They live on aquatic plants. Such are ELODES[3] of Lat. (*Cyphon*, Fab. Steph.), of which the hind thighs differ but little in thickness from those of the preceding genus (we have seventeen kinds in Britain), and SCYRTES, Lat. of which the species are leapers, with the posterior thighs very large, and the tibiæ terminated by two strong spurs.

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[1] *Règne Animal*, t. iv. p. 445.

[2] *Ibid.* note. See also *Nouvelles Annales du Mus. d'Hist. Nat.* t. ii. p. 66.

[3] *Zoological Journal*, vol. iii. p. 379.

[4] From κτεις, *a comb*, and κεϱας, *a horn.*

[5] For the British genera and species, see the works of Messrs Curtis and Stephens. Such as have been hitherto ascertained to inhabit Scotland are described in *Entomologia Edinensis*, p. 192–9.

[6] From καταφαγω, *I devour.*

[7] The modern genera of Elaterides are far too numerous to admit of being even named in our present article. We refer the reader, in addition to the systematic works of Fabricius, Olivier, and Latreille, to Palisot de Beauvois's *Insectes d'Afrique et d'Amerique*, Dalman's *Analecta Entomologica*, and the beautiful monograph by Count Mannherheim entitled *Eucnemis Insectorum genus.*

[8] From μαλακος, *soft*, and δεϱμα, *skin.*

[9] The *Cebriones* may be said to constitute an exception to this negative character, and thus approximate the Elaterides; but the inferior extremity of the præsternum does not advance under the head.

[10] Aristophanes applies the name Κεϐϱιον to a species of bird.

TRIBE 2D, LAMPYRIDES.

This tribe is distinguished from the preceding by the enlarged termination of the palpi, at least of those of the maxillæ; by their straight, depressed, but slightly convex body; and by the thorax, sometimes semicircular, sometimes nearly square or trapezoidal, projecting over and almost concealing the head. The mandibles are generally small, and terminate in a slender, arcuated, very acute point, generally entire. The penultimate joint of the tarsi is always bilobate, and the terminal hooks have neither dentations nor appendages. The females of some are apterous, or have but short elytra. When seized, most of these insects press their feet and antennæ close to the body, and remain as motionless as if they were dead. Several curve the abdomen underneath. They correspond to the old genus *Lampyris* of Linn., and include some species remarkable for their phosphorescent or luminous qualities.

1st, Antennæ approximated at the base, the head either prolonged anteriorly in the manner of a snout, or for the greater part, or entirely, concealed beneath the thorax. Eyes of the males large and globular. Mouth small.

Here we place the following genera, in all of which the head is exposed:—*1st*, LYCUS,[4] Fab. In this the snout is as long as the preceding portion of the head, or longer, and the antennæ serrated. The elytra are generally dilated, either laterally, or at their posterior extremity, the two sexes (particularly of certain African species) differing greatly in that respect; *2d*, DICTYOPTERA, Lat. (Plate CCXXIII. fig. 2); and, *3d*, OMALISUS,[5] Geoffroy (ibid. fig. 4). The remaining insects of this division are distinguished from the preceding, not only by the want of a snout (it is not apparent even in the last-named genus), by their head, which in the males is almost entirely occupied by the eyes, and much concealed by the square or semicircular thorax—but more particularly by a very remarkable character, either common alike to males or females, or peculiar to the latter sex, viz. the property of phosphorescence. Hence the names of glow-worms, fireflies, &c. bestowed upon the species which form the genus LAMPYRIS properly so called.[6]

In regard to the general history of these insects, we may observe, that the Greeks applied the name of *Lampyris*, and the Latins those of *Noctiluca*, *Luciola*, &c. without any very special reference, to such insects as were observed to shine during the night with a lambent or phosphoric flame. They were long confounded with *Telephorus* and *Malachius* under the genus *Cantharis*. Geoffroy effected their separation from Telephorus, and placed them in the genus *Lycus*, while Linnæus also combined them with that genus and *Pyrochroa*. Fabricius was the first to restrict and define the genus with propriety.[7] The antennæ are short, the articulations cylindrical and compressed. The head is concealed beneath the anterior margin of the thorax, which is semicircular in the indigenous species. The eyes are large. The body rather soft, oblong-oval, much depressed. The abdomen is serrated on its lateral edges. The elytra are coriaceous, and slightly flexible. The legs are compressed and simple. The females are apterous, with the rudiments of elytra at the base of the abdomen. Other characters are minutely detailed by systematic writers, which we need not here enter into. We shall, however, record some observations, both of a general and particular nature, which we were induced to make in consequence of our having kept the common British glow-worm in confinement.[8]

The beautiful light which emanates from this insect constitutes its most interesting and peculiar attribute. If several ancient nations were worshippers of the sun, and regarded "holy light" as a divine effulgence, the offspring of heaven, and the purest of the elements, we need scarcely wonder that in remote times, when natural phenomena were but slightly understood, even the more obscure manifestations of a supposed celestial principle should have excited the wonder and admiration of mankind. We consequently find many exaggerated accounts of the cause and effects of these flying and creeping lights, which, as they do not illustrate the natural history, properly so called, of the insects themselves, we shall leave for the pre-

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[1] From ϱιπὶς, *a fan*, and κεϱας, *a horn*.

[2] *Linn. Trans.* vol. xii. pl. 21, 3.

[3] From ἕλος, *a marsh*, the species usually frequenting moist places.

[4] From λυκοῶ, *I destroy*.

[5] Perhaps from ομαλος, *flat*.

[6] The word λαμπυϱος occurs in Aristotle, and is derived from λαμπτω, *to shine*, and πυϱ, *fire*. The genus in its undivided state is very extensive, containing not fewer than sixty species. We observe, however, that in the last edition of Dejean's Catalogue, so many divisions have taken place, that the genus Lampyris, properly so called, is now made to consist of only *nine* species. It is very poorly represented in Britain, and indeed produces but few European examples. If, as Mr Stephens supposes, *L. splendidula* has been erroneously introduced into the British Fauna, then *L. noctiluca*, Linn., may be regarded as the sole indigenous species. Some Brazilian species, in which the antennæ of the males consist of more than eleven joints, formed like the laminæ of a feather, constitute the genus *Amydetes* of Hoffmansegg. Others, also peculiar to South America, and of which the antennæ consist of only eleven joints, form the genus *Phengodes* of that author. (Illiger's *Mag.* vi. p. 342.)

[7] For representations of the glow-worm (*L. noctiluca*), see Plate CCXXIII. Fig. 5 is the winged male; fig. 6 the wingless female; fig. 7 the larva; fig. 10 represents a large and remarkable species, the *Lampyris Savignii* of Kirby.

[8] We here in part avail ourselves of what we have already stated in the *Entomologia Edinensis*, p. 202–7.

Coleoptera Pentamera.

sent unrecorded. But the actual phenomena are extremely interesting, on account both of their singularity and beauty, and, without the aid of fiction, are well deserving the attention of the poet and philosopher. Huet, bishop of Avranches, an eminent scholar, composed a poem, entitled *Lampyris;* and the masterly genius of Wordsworth, which draws so much that is new and beautiful from the observance of common things, has not failed to immortalize the radiance of the "earth-born star." "And if," say Messrs Kirby and Spence, or one or other of these authors, while speaking of the British glow-worm, "living like me in a district where it is rarely met with, the first time you saw this insect chanced to be, as it was in my case, one of those delightful evenings which an English summer seldom yields, when not a breeze disturbs the balmy air, and hundreds of these radiant worms, studding their mossy couch with mild effulgence, were presented to your wondering eye in the course of a quarter of a mile,—you could not help associating with the name of glow-worm the most pleasing recollections. No wonder that an insect which chiefly exhibits itself on occasions so interesting, and whose economy is so remarkable, should have afforded exquisite images and illustrations to those poets who have cultivated natural history."[1] However beautiful the effect produced by our own species, and by the fire-flies (*L. italica*), which are still more abundant over Italy and the rest of the south of Europe, their splendour, according to Humboldt, cannot be compared in richness to those innumerable scattered and moving lights that embellish the nights of the torrid zone, and seem to repeat on earth, along the vast extent of the savannahs, the spectacle of the starry vault of heaven. These, however, belong to a different tribe of insects (Elaterides), which resemble the glow-worm merely in their luminous properties; yet we cannot resist quoting the beautiful lines by Mr Southey, in which he describes their first effect on the earliest visitors of the new world.

> .... Sorrowing we beheld
> The night come on; but soon did night display
> More wonders than it veiled; innumerous tribes
> From the wood-cover swarm'd, and darkness made
> Their beauties visible: one while they streamed
> A bright blue radiance upon flowers that closed
> Their gorgeous colours from the eye of day;
> Now motionless and dark, eluded search,
> Self-shrouded; and anon, starring the sky,
> Rose like a shower of fire.[2]

The glow-worm is now a very rare insect in the neighbourhood of Edinburgh. Mr Neill informs us that it formerly occurred between the city and the village of Canonmills; but we have not heard of its having been found there or elsewhere around our immediate suburbs for many years. Dr David Ritchie has observed it occasionally near Pathhead, and Professor Wallace has met with it in Fife. Professor Wilson informs us that he once saw it on the Queensferry road, near Comely Bank. We have ourselves taken it by Loch Lomond side, and elsewhere in Scotland. It abounds in the north of England. We once received some living specimens early in July from Borthwick, about twelve miles from Edinburgh. They laid eggs a few days after their arrival, on the sides of a glass vessel. The parents soon after died, probably from being kept in too confined a space; but the young larvæ were hatched in a few weeks, and by the end of September they measured about the third of an inch in length. These larvæ bear a strong resemblance to the female perfect insect. The body is composed of twelve segments, of which the central are the largest. The three first segments bear each a pair of feet, and the caudal segments are slightly retractile within each other; and when the insect walks, which it does very leisurely, it bends its tail beneath it in such a way as to assist or support it in its progress. The head is very small, and is also retractile, and is usually withdrawn whenever the insect is alarmed or disturbed. These little creatures throve well in captivity. They were kept on a piece of moist mossy turf, which was frequently renewed; but whether they sustained themselves on the dewy herbage, or by means of the minute animal substances which it contained, it was not for a time very easy to discover. The curved and extended form of the little jaws would in the first place induce one to suppose that they were carnivorous. Olivier, however, observes, in his description of the larva of the glow-worm, "elle vie cependant sur de la terre fraîche, avec de l'herbe et des feuilles des différentes plantes; mais l'on a remarqué qu'elle devient foible et languissante, quand on la laisse manquer de terre humide. Elle est très-pacifique, et paroit craintive."[3] Fresh earth, or the moisture which arises from it, certainly seems necessary to their welfare, for we noticed that, when their turf became dry, and a slice of fresh apple or potato was introduced, they immediately settled on it, and inserted their heads as if drinking. We, however, soon after detected one with its jaws fixed in the head of a minute snail, which it appeared to be devouring, its own head being inserted into the aperture of the shell.

This observation appeared the more interesting, in as far as it served to connect those insects, by means of their habits, with that singular species the *Drilus flavescens*, which is known to feed voraciously on the *Helix nemoralis*, and the female of which was described by Mielzinski as the type of a distinct genus, under the name of *Cochleoctonus*. This latter insect is parasitical on the body of the helix, in the shell of which it dwells and undergoes its metamorphoses.

While engaged in the observance of these glow-worms, we met with a notice, in the *Annales des Sciences*, by a French gentleman of Rouen, on the same subject. In it we have ample proof of the carnivorous propensities of the creatures in question. He placed a great number of the larvæ in a vessel with fresh earth, and supplied them with various kinds of leaves. They soon however became extremely feeble, and remained so for several weeks, when he happened to put a dead slug in their jar, of which the young glow-worms were no sooner aware than they greedily seized upon it with their arched and sharp-pointed mandibles. On the ensuing day they were found to have eaten their way so far into the slug, that nothing but their tails was visible. They were perceived however occasionally to quit their prey and walk about upon the moist earth. The French naturalist was curious to observe how they would proceed with a living snail, and he therefore introduced one into his colony of insects. The animal soon began to crawl about its new domicile, but it no sooner came upon the path of a glow-worm than it was seized by the latter immediately beneath the mouth, and with such force and tenacity that it drew itself suddenly into its shell, and of course dragged its enemy along with it. The glow-worm however immediately disengaged its hold, and struggled back to the mouth of the shell, on the back of which it soon mounted, thus keeping the snail in a state of siege. Whenever it protruded even the point of its horns it was instantly seized, bitten, and obliged to withdraw within its fortress. The larva being soon joined by a companion, the two attacked the unfortunate snail, and

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[1] *Introduction to Entomology*, vol. ii. p. 410.

[2] *Madoc.*

[3] *Entomologie*, t. ii. No. 28, p. 7.

after a continued combat of several hours, they put it to death, and by next morning it was not only slain, but eaten. These and similar experiments were made from the month of November to the month of June, after which the larvæ were observed to undergo their transformations. They occupied about a week in assuming the state of nymph—they continued in that state eight days longer—and then appeared in the form of the perfect insect. When about to assume the nympha state, the skin of the upper and anterior portion of the body cracks and opens, or a lateral division takes place on either side, so as to separate the skin of the upper from that of the under portion. By alternate elongations and contractions they then work their way forwards, and contrive to effect their liberation in a few minutes from their old attire. The nymph is larger than the larva, though not quite so long. Its colour is at first pale yellow, with two reddish spots on the posterior and lateral portion of each segment of the abdomen, as well as on the posterior angles of the thorax. It wants the large acute mandibles of the larva; its antennæ are very obvious, and consist of eleven articulations. The tarsi are likewise distinctly composed each of five articulations. The last rings of the abdomen are very brilliant, especially when the insect is handled; and it was noted as remarkable that the whole body partook, though with less intensity, of that phosphoric splendour which in the perfect insect characterizes only the terminal segments of the abdomen. Before the termination of the eight days which are passed in the nympha state, all the more delicate colours had disappeared, and were finally converted into those duller hues which distinguish the insect in its matured condition. As soon as it has disengaged itself from the slough of the larva, it bends its body into an arch or semicircle, and is then a genuine nymph, although it still continues to move its head, and even its limbs and antennæ. In this intermediate condition its general form has undergone no great change, but the head, feet, and antennæ are considerably altered, and seem enlarged or swollen. At first the body manifests a slow and heavy movement, which ere long ceases, and the antennæ and feet are then applied more closely to the sides of the body. The only signs of life now consist in a movement of the abdomen, which is bent into an arch, or occasionally moved from side to side. The body is shorter than that of the larva, the head is bent beneath the first segment or thorax, the antennæ consist of numerous articulations, and the caudal segment of the body, instead of being terminated by a couple of points, is now surrounded by eight of those points, in the centre of which are two fleshy tubercles, placed in a slight depression. Olivier had previously informed us that the nymph, after quitting the skin of the larva, shone with a very lively and brilliant light of a beautiful green colour, which became more splendid for a time when the vessel which contained it was moved, and disappeared again, as if by some voluntary action of the animal, even in the nympha state, in which the vital and instinctive powers are usually almost in a state of suspension. According to Degeer, the larva is also luminous. We did not however observe any manifestation of that faculty in those in our keeping.

It has been a frequent subject of inquiry to ascertain the purposes which the light is intended to serve. In the perfect state the female continues wingless, while the male has become a swift-flying insect; and this has led to the supposition that the lambent flame, which is always most conspicuous in the female, is intended as a "nuptial lamp," to guide the male to her society. In this case, however, we do not so clearly see the use of it in the larva and nympha states, unless, to be sure, as a preparatory process for the formation of the animal phosphorus. Although many insects discover each other merely by the sense of smell, the fact seems nearly certain that the male or winged glow-worm ascertains his mate by aid of her luminous property; for it is a well-known and successful entomological device to place a female in a conspicuous position, and watch by her side, with a view to entrap the rarer or less visible males, which ere long make their appearance. Olivier has frequently caught the males by holding a female on the palm of his hand,—which makes it the more singular that he did not perceive the two luminous points which the former bears on the last segment of the abdomen,—"Je n'ai pas encore m'assurer, il est vrai, si le mâle de notre espèce commune a la propriété de luire." We may add, that the eggs are also beautifully luminous for some time after they are laid.

Dufour has examined the anatomical structure of the female glow-worm. The alimentary canal measures about twice the length of the body. The œsophagus is so short as to be nearly imperceptible. It dilates immediately into a short crop. The chylific ventricle is separated from the crop by a valvular contraction. It is long, smooth, that is, unprovided with papillæ, but pursed and cylindrical in its two anterior thirds, and intestiform in the remainder. The small intestine is very short.[1]

The matter from which the luminous property of the glow-worm results has been the subject of frequent experiment and observation. It is obviously under the control of the insect, which, when approached, may frequently be observed to diminish or put out its light.[2]

In the perfect female the luminous matter occupies chiefly the inferior part of the three last annuli of the abdomen. These differ from the rest in colour, and are usually of a yellow hue, especially on the under side. The light diffused is more or less intense, according to circumstances. The insect lives for a considerable time in a vacuum, and in various gases; but in nitrous acid, muriatic and sulphurous gases, it soon expires. When placed in hydrogen gas it has sometimes been observed to produce detonation. When the luminous portion of the body of a glow-worm is cut off, the insect continues to live, and the separated segments retain their phosphoric nature, and are luminous for some time, whether placed in vacuum, exposed to the air, or submitted to the action of different gases. By what means the living insect is able to shroud itself in darkness, and then suddenly to clothe itself as it were in a mantle of radiant light, is a subject beyond our power of investigation; but when dried the phosphorescence seems to depend on a certain degree of softness or humidity; for when apparently quite extinct, it may be reproduced by pressure, and the application of a little moisture. In the living state, however, although immersion in warm water produces a brilliant light, the application of cold water tends to its speedy extinction.

The next peculiarity in the history of the glow-worm consists in the change of its habits in regard to food, which takes place on its attaining maturity. From an insect of a predaceous nature, greedy of animal juices, it becomes entirely herbivorous, not much addicted indeed to food of any kind, but still confining itself, when it does indulge in eating, to the tender leaves of plants. It is this circumstance which has no doubt led to so much contrariety of opinion on the part of entomological writers regarding its natural disposition. Most observers having attended to it chiefly after it had undergone its transformations, they naturally, and so far correctly, concluded that it was a herbivorous insect. Had they watched its progress from the egg they would have come to another conclusion, at least in regard to its earlier condition. This alteration in the habits of these creatures is in fact by no means unexampled, either among other genera of the same class, or among the more distantly related reptile tribes. The most familiar instance among the latter is the common frog, which in the early state of tadpole is herbivorous, while under the perfect form it preys on flies and other insects. In this case, to be sure, the order of change is inverted, the alteration being from a herbivorous to a carnivorous diet; while the contrary takes place in the glow-worm. But the analogy is more strictly maintained in the case of those aquatic beetles which form the family of *Helophoridæ*, which in the larva state are carnivorous, but become herbivorous after assuming their final transformation. The same singularity is also illustrated by many dipterous flies, which, born and bred amid the putrid moisture of animal remains, no sooner become winged insects, than they seek a purer diet in the nectarous juices of fruits and flowers.

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[1] *Ann. des Sciences Nat.* t. iii. p. 225.

[2] On this curious subject, however, we beg to refer the reader to the writings of Beckerheim (*Ann. de Chimie*, t. iv. p. 19), Caradori, and Treviranus, among foreign authors,—and to those of Mr Macartney (*Phil. Trans.* 1810), and Kirby and Spence (vol. ii. p. 423), among ourselves.

In relation to the glow-worm, the observation is of more practical interest, because the appearance of the insect among our lawns and shrubberies is so extremely ornamental during the summer nights, that many have tried to import it to districts where it does not naturally occur. They have failed, in consequence of endeavouring to rear the young on vegetable food. Moist herbage, or a supply of damp earth, seems almost indispensable; but, in addition to these, their box must contain some minute testacea, such as the young of the ordinary species of the genus Helix. Perhaps the best plan is to hatch the eggs, and then place the young at liberty under an old hedge as soon as they have begun to eat freely.

2*d*, Antennæ decidedly remote at their base; head neither prolonged nor narrowed anteriorly in the form of a snout; the eyes of ordinary size in both sexes.

In genus DRYLUS, Oliv. (Plate CCXXIII. figs. 8, 9, and 12), the males are winged, and the inner side of the antennæ, from the fourth joint, is prolonged like the tooth of a comb. Those of the female are shorter, or somewhat perfoliaceous, and slightly serrated. The maxillary palpi in both sexes are thicker towards the extremity, and terminate in a point. There is a tooth on the internal side of the mandibles. The *D. flavescens* (see figs. last referred to) feeds, while in the larva state, on the *Helix nemoralis* of Linn. in the shell of which it dwells and undergoes its metamorphosis. It was on this account described by Comte Mielzinsky under the name of *Cochleoctonus*. Its history, and that of the other species, are now well known.[1]

All the remaining genera of this second division of the *Lampyrides* are winged in both sexes, and the maxillary palpi are not much longer than the labial. They correspond to the family *Telephoridæ* of English naturalists, and are composed chiefly of the species placed by Linnæus under the genus *Cantharis*. Schœffer and Degeer reserve that name to the species used in medicine, and apply the term Telephorus (probably from *θελος φορεω*, *I carry death*) to the remainder. The true Cantharidæ, therefore, are constituted by the genus Meloe, and the well-known blister-fly *C. vesicatoria*, &c.

In the genus TELEPHORUS (Plate CCXXIII. fig. 11) the palpi are terminated by a securiform article, and the thorax offers no lateral emarginations. Their bodies are long, narrow, depressed, and of a soft or somewhat flexible consistence. These insects abound in meadows during the summer season, on umbelliferous and other plants. The larvæ are characterized by a flat scaly head, furnished with two strong teeth, a pair of small antennæ, and four palpi. Their bodies are flattish beneath, divided into twelve rings resembling those of caterpillars, and covered by a membranous skin, which is soft to the touch. The general colour of these larvæ is a deep velvety black, except the front of the head, which is shining. The antennæ, palpi, and feet are of a reddish or yellowish brown. They dwell in moist earth. Olivier was of opinion that they fed on roots, but the laborious and accurate Degeer asserts that they voraciously devour a great variety of insect prey. That of *Telephorus fuscus* was observed to change into the nympha state towards the end of May. It buried itself in the earth, but presented no appearance of cocoon. The nympha was about six lines in length, with the body somewhat arched, and of a pale-reddish white. The perfect insect was developed in the month of June. Even in the last-named state, in which so many species are chiefly occupied in the indulgence of other propensities, the Telephori, according to Degeer, continue their accustomed appetite. He has observed a female drag a male to the ground, turn him on his back, and suck out his entrails; so that, as among the spider tribes, considerable caution is necessary on the part of an inexperienced suitor while making his advances. Mr Curtis has frequently seen Telephori with other insects in their mouths. He once observed *T. lividus* eating an ichneumon, and he took another of the same species with an Empis in its mouth. *T. fuscus* is known to prey upon its own species. There are above thirty different kinds of this genus in Britain. Dejean, under the Linnæan name of *Cantharis*, enumerates 132 species. Whatever we know of the anatomy of these creatures accords with their apparent dispositions. Dufour has ascertained that their digestive canal is absolutely straight. Their biliary vessels are four in number, in which character, as well as in that of their generative system, they present a resemblance to the genus Lycus.

One of the most remarkable incidents in the history of the Telephori is the frequency with which, in some continental countries, the species are carried into the air in great quantities by violent winds, and unexpectedly deposited in distant regions,—thus giving rise to what are called *insect showers*. Sweden and Hungary have been most productive of such phenomena. One of the most ornamental of the British species, and the only one we shall here describe, is *T. cyaneus* of Curtis. The head is black and shining, but rufous before the eyes; the thorax and abdomen are likewise rufous, the elytra are deep blue, the legs black. This insect is pretty widely, though sparingly, distributed over the southern and central counties of Scotland, and the north of England. We have specimens from the Edinburgh district, from Kinordy in Forfarshire, from Dollar in Clackmannanshire, and from Dumfries and Roxburgh shires.

The genus SILIS of Megerle differs from the preceding chiefly in having an emargination posteriorly on each side of the thorax. In MALTHINUS of Lat. (Plate CCXXIII. fig. 14) the palpi are terminated by an ovoid joint; the head is narrow behind; and the elytra, in several species, are shorter than the abdomen.

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[1] See *Annales des Sciences Nat.* Jan. Juil. Aout, 1824; and *le Bulletin de la Soc. Phil.* for April of the same year.

Tribe 3d, Melyrides.

Here we find the palpi generally short and filiform; the mandibles emarginated at the point; the body usually narrow and elongated; the head only covered at base by a flat or but slightly convex thorax, generally square, or elongated and quadrilateral; the joints of the tarsi entire, and the terminal hooks unidentated or bordered with a membrane. The antennæ are usually serrated, and even pectinated, in the males of several species. Most of these insects are of active habits. They occur on the leaves and flowers of plants.

In Malachius[1] of Fab. (Plate CCXXIII. fig. 13), there is a retractile and dilatable vesicle under each anterior angle of the thorax, and on each side of the base of the abdomen. Most of the species are adorned by ornamental and contrasted colours. The habits of the larvæ are but obscurely known. Olivier presumes that many of them live in wood, because he has frequently found the perfect insect in timber-yards, as if newly escaped from the nympha state. This is an extensive genus, and may be regarded as characteristic of temperate climes, although a few occur in Africa and the East Indies. Mr Stephens enumerates seventeen British species. Comte Dejean's collection contains 104 in all. Among the Melyrides with filiform antennæ, but of which the thorax and abdomen are unfurnished with retractile vesicles, Latreille places the genus Dasytes[2] of Paykul. The antennæ are at least as long as the head and thorax; and the body is generally narrow and elongated, sometimes linear. We have figured the male of *D. ater* (Plate CCXXIII. fig. 15). In Melyris properly so called (Plate CCXXIII. fig. 16), the antennæ are shorter than the head and thorax, insensibly enlarged, but without forming a club, as in *Lygia*. Their joints are also less dilated laterally, and are almost isometrical. The thorax is less convex.

In other Melyrides, such as Pelocophorus of Dej. the maxillary palpi are terminated by a larger and securiform article, a character which, with certain others, approximates them to the ensuing tribe. Dejean at one time placed them among the *tetramerous* species.

Tribe 4th, Clerii.

Distinguished by at least two of the palpi being projecting and clavate. The mandibles are dentated. The penultimate joint of the tarsi is bilobate, the first very short or but slightly visible in several. The antennæ vary, being in some nearly filiform and serrated, in others insensibly enlarged towards the extremity. The body is usually cylindrical, the head and thorax narrower than the abdomen, and the eyes emarginate. Most of these insects occur on flowers, some of them on the trunks of trees or in dry timber. The larvæ are regarded as carnivorous.

Of some the tarsi, viewed from above or from beneath, distinctly exhibit five joints. Such is the genus Tillus[3] of Olivier, in which the mandibles are cleft or bidentated at the extremity; the antennæ sometimes serrated, from the fourth joint to the tenth inclusively, with the last ovoid, sometimes terminating suddenly from the sixth in a serrated club. The terminal joint of the labial palpi is very large and securiform; the head short and rounded, and the third and fourth joints of the tarsi dilated in the form of a reversed triangle.

Of others the tarsi, when viewed from above, appear to consist of only four joints, the first being extremely short, or concealed beneath the second. Such is the genus Clerus[4] properly so called (Plate CCXXIII. fig. 17), in which the maxillary palpi are terminated by a compressed joint in the form of a reversed triangle, the last of the labial palpi, which are larger than the others, being securiform. The club of the antennæ is hardly longer than wide, and is composed of crowded joints; the third is longer than the second. The maxillæ terminate in a fringed and projecting lobe. The thorax is depressed anteriorly. The species, in the perfect state, occur on flowers. Their larvæ feed on those of certain bees. Dufour has described their internal structure. The crop is so short as to be almost entirely contained within the head. In Necrobia,[5] Lat. (Plate CCXXIII. fig. 19), the four palpi are terminated by an elongated, compressed, triangular joint of the same size; the second and third joints of the antennæ are almost equal, and the terminal club is elongated, and with looser articles. These insects occur chiefly in spring. They are said to live on carrion, and are richly adorned for such foul feeders. Deep blue is their prevailing colour. There are four species in Britain, of which we have as yet found only two in Scotland, viz. *N. ruficollis*, of a greenish blue, the thorax, base of the elytra, and legs rufous,—*N. violacea*, of a bright blue, shining yet pubescent, the antennæ and legs black. If the geographical notices which we have collected of the former species be correct, its distribution must be very extensive. It seems to occur both in Africa and the East Indies,—a wide circuit for an insect which we have taken behind the glass-works at Leith. "Insectum mihi carissimum," says Latreille, "illis enim infelicissimis temporibus quibus calamitatum omnium pondere obruta Gallia trepidanter gemebat, amicissime auxiliantibus Bory de Saint Vincent, Dargelas, Burdigalensibus, posteriori maxime, hoc animalculum mihi libertatis salutisque occasio miranda evasit."[6]

Tribe 5th, Ptiniores, Lat.

This tribe, consisting of the genus Ptinus of Linnæus, and of some others nearly allied, possesses a body of a tolerably firm consistence, in some cases almost ovoid or oval, and at others nearly cylindrical, but generally short, and rounded at either end. The head is nearly globular or orbicular, and is received almost entirely into a strongly arched or rounded thorax, resembling a hood. The antennæ of some are filiform, or diminished towards the termination, and are simple, flabelliform, pectinated, or serrated; of others they are terminated suddenly by three larger and longer joints. The mandibles are short, thick, and dentated beneath the point. The palpi are very short, and terminated by a larger article, almost ovoid, or like a reversed triangle. The tibiæ are not dentated, and the spurs at the extremities are very small. These insects are all of small size, exhibit little variety in their colouring, which is usually dark or sombre, and when touched they counterfeit death. Their motions are slow, and such as are winged seldom take to flight. In the larva state they are extremely destructive in museums.

In the genus Ptinus (Plate CCXXIII. fig. 18) properly so called, the antennæ are as long as the body, and inserted between the eyes, which are somewhat protuberant. The body is oblong. In the genus Ptilinus, Fab. (ibid. fig. 20), the antennæ, inserted before the eyes, are shorter than the body, and are pectinated or plumose from the third joint in the males[1]—serrated in the females. They inhabit old wood, in which they perforate deep round holes. In ANOBIUM, Fab. the antennæ are terminated by three larger or longer joints, the terminal one being ovate. The name of *Byrrhus*, originally bestowed upon the insects of the last-named genus by Geoffroy, was transferred by Linnæus to a very different group. His genus *Ptinus* included both *Ptilinus* and *Anobium*. Fabricius was the institutor of the genus Anobium, so called from *αναϐιον*, *resuscitated*,—the species being characterized, in common with most of their congeners, by their frequent simulation of death, and their re-assumption of activity as soon as the threatened danger is removed. In this instinctive mode of preservation Olivier accuses them of exhibiting an invincible obstinacy. “Ils se laissent entièrement bruler sans donner aucun signe de vie.” The larvæ of these insects are extremely injurious to old furniture, in which they perforate numerous round holes. Hence the genus is named vrillette by the French, from *vrille*, a gimlet. In the larva state they resemble small, white, soft worms, with six short minute feet. The head is scaly, and is terminated by two maxillæ in the form of strong cutting pincers, with which they gnaw the wood into the finest sawdust. When about to change into the nympha state, they line the bottom of their little cells with a few silken threads. Other species feed on flour, bread, sealing-wafers, &c. where they form grooves or galleries, according to the thickness of their working materials. The superstitious fancy of the *death-watch* has arisen partly from an insect of this genus, the *An. tessellatum*. It is supposed, however, to share this mysterious calling with the *Termes pulsatorium* of Linnæus, and probably with several others. According to Dr Shaw, it is in the advanced state of spring that the former of these insects commences its mysterious pulsations, which, he asserts, is nothing more than the signal-call of the sexes. The number of distinct strokes is generally from seven to eleven, and these are occasioned merely by its beating with its head with considerable force and quickness against the plane of its position. Where the insects are numerous, as is not unfrequently the case in old houses, these sounds may be heard during the whole day, especially in warm weather. The sound greatly resembles a moderate tapping on a table with the finger nail, and indeed by that simple process they may be induced to beat in reply when not otherwise inclined so to do. “He that could eradicate this error,” says the quaint Sir Thomas Brown, in allusion to the death-tick, “from the minds of the people, would save from many a cold sweat the meticulous heads of nurses and grandmothers.”[2] One of the most common species of the genus is *Anobium striatum*, of a somewhat pitchy-brown colour, the thorax obsoletely grooved, and produced towards the base into an elevated triangular ridge. This little timber borer, which is the *A. pertinax* of Fabricius, has been long famous for a most *pertinaceous* simulation of death. “All that has been related of the heroic constancy of American savages when taken and tortured by their enemies, scarcely comes up to that which these little creatures exhibit. You may maim them, pull them limb from limb, roast them alive over a slow fire,[3] but you will not gain your end; not a joint will they move, nor show by the least symptom that they suffer pain. Do not think, however, that I ever tried these experiments upon them myself, or that I recommend you to do the same.”[4] This species was observed by Latreille to produce the sound called the *death-tick*, by striking its mandibles upon wood. On this occasion it was immediately answered from within by a precisely similar sound. We took a very rare British species, *A. abietis*, Fab. many years ago in a fir-wood near Edinburgh. *A. erythropum* of Leach is also stated by Mr Stephens to have been taken at Ravelston.

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[1] From μαλακος, *soft.*

[2] From δασυτης, *shagginess.*

[3] From τιλλω, *to pluck or pull out.*

[4] The word κληρος is applied by Aristotle to an insect which inhabits hives.

[5] From νεκρος, *curcass*, and βιος, *life.*

[6] *Genera Crust. et Insect.*

SECTION 3D, XYLOTROGI, Lat.

This final section of the SERRICORNES is distinguished from the two preceding by the freedom of the head, which is completely exposed and separated from the thorax by a strangulation or species of neck. It is composed entirely of the genus *Lymexylon* of Fab. as subdivided by recent writers.

In ATRACTOCERUS of Palisot de Beauvois, the elytra are extremely short, and in the form of little scales; the antennæ are compressed and almost fusiform; the thorax is square, the abdomen depressed. This limited and very anomalous-looking genus (it has the aspect of a *Staphylinus*) has representatives in Guinea, Brazil, and Java. A species is likewise known to occur in amber. In LYMEXYLON,[5] Fab. the elytra are as long or little shorter than the abdomen, the antennæ are simple, slightly if at all compressed, and almost moniliform. The thorax is nearly cylindrical. The *L. navale*, Fab. (of which *L. flavipes* of the same author is the male), is a small narrow insect of about half an inch in length, of a pale fulvous colour; the head, exterior margin, and extremity of the elytra black,—the latter colour more predominant in the males. This species is extremely common in the oak forests of the north of Europe, although unknown in Britain, and rare in the vicinity of Paris. Its larva is so long and slender as almost to resemble a *Filaria*. It multiplied so prodigiously some years ago in the dock-yards at Toulon, as to cause the destruction of great quantities of timber.[6]

FAMILY IV.—CLAVICORNES, LAT.

In this family, as in the preceding, we find four palpi, and elytra covering the upper surface of the abdomen, or its greater portion; but the antennæ are almost always thicker at the extremity, which frequently forms even a perfoliaceous or a solid club; they are longer than the maxillary palpi, and their base is exposed or scarcely covered. The legs are not fitted for swimming, and the joints of the tarsi, at least of the posterior ones, are usually entire. In the larva state they feed on animal matter. Latreille divides the tribe into two sections.

SECTION 1ST. Antennæ always composed of eleven joints, longer than the head, not forming from the third articulation a fusiform or nearly cylindrical club; the second joint not dilated in the form of an auricle. The terminal joints of the tarsi, as well as its hooks, of moderate length, or small. All the genera of this section are terrestrial. It comprises several tribes.

TRIBE 1ST, PALPATORES.

These, in a natural series, should be placed near the Pselaphii and Brachelytrous genera. Their antennæ are at least as long as the head, are slightly enlarged towards the extremity, or are nearly filiform; their first two joints are longer than those that follow. The head is distinguished from the thorax by an ovoid strangulation. The maxillary palpi project, and are long and inflated at the extremity. The abdomen is large, oval or ovoid, and laterally embraced by the elytra. The legs are elongated, the thighs clavate, the joints of the tarsi entire. These insects are found on the ground beneath stones and other substances. They form a single genus, divided by some writers into MASTIGUS and SCYDMÆNUS. The latter frequent moist places.

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[1] The generic name is no doubt derived from πτιλον, *a feather*,—in reference to the form of the antennæ.

[2] *Pseudodoxia Epidemica.*

[3] Degeer, iv. 229.

[4] *Introd. to Ent.* vol. ii. p. 235.

[5] From λυμη, *destruction*, and ξυλον, *wood.*

[6] *Règne Animal*, t. iv. p. 369.

In all the following Clavicornes the head is generally sunk in the thorax, and the maxillary palpi are never at the same time advanced and club-shaped.

TRIBE 2D, HISTEROIDES.

This tribe is composed of the great genus *Hister* of Linnæus. The four posterior legs are more widely separated from each other at their origin than the anterior pair. The legs are contractile, and the exterior tibiæ dentated or spinous. The antennæ are always bent or *elbowed* (geniculate), and terminated in a solid mass, or composed of close-set articulations. The body is of a very solid consistence, and the elytra so hard that even the pin of the entomologist is with difficulty made to enter, and the præsternum is often dilated in front, and the elytra truncated. The mandibles are strong, and not unfrequently unequal as to size. The palpi are almost filiform, or slightly enlarged at their extremity, and terminated by an oval or ovoid article. In respect to their habits, the dentation of their tibiæ, and some other circumstances, these insects seem to exhibit an approach to the coprophagous LAMELLICORNES; but both Dufour[1] and Latreille[2] are of opinion that well-founded anatomical considerations connect them with the SILPHÆ. In the species (*H. sinuatus*) dissected by the former author, the digestive canal was found to be four or five times as long as the body. The œsophagus is extremely short; the oblong enlargement which immediately succeeds it exhibits throughout its parictes some brownish lines, which seem to indicate the existence of interior appendages proper for trituration; and if so, such enlargement may be regarded as the gizzard. The chylific ventricle is very long, twisted on itself, and beset with pointed and projecting papillæ. The hepatic vessels have six distinct insertions around the chylific ventricle.[3]

These insects feed on putrid and stercoraceous substances, decaying vegetables, &c. and some dwell beneath the bark of trees. Their movements are slow, their colour blackish, frequently with a tinge of bronze. Such of the larvæ as are known to naturalists affect the same food as the perfect insect. Their form, however, is different, being almost linear, depressed, smooth, soft, and of a yellowish white, with the exception of the head and first segment, of which the skin is scaly and of a brown or reddish colour. These larvæ have six short legs, and are terminated by a pair of articulated appendages, and an anal prolongation or tube. The scaly shield of the first segment is longitudinally channelled.

In some the tibiæ, at least the anterior ones, are triangular and dentated, and the antennæ always free and exposed, the body square, and slightly if at all inflated. Such is the genus HOLEPTA of Paykul, in which the body is much depressed, the mentum deeply emarginate, and the palpi formed of almost cylindrical joints. The species dwell beneath the bark of trees. In HISTER[4] properly so called (Plate CCXXIII. fig. 22), the præsternum projects beyond the mouth, and the palpi are composed of joints, the last excepted, rather in the form of a reversed cone than cylindrical.[5]

TRIBE 3D, SILPHALES.

In these and the remaining CLAVICORNES the legs are inserted at an equal distance from each other, and, with the exception of the eighth tribe (BYRRHII), the legs are not contractile, or at most the tarsi only can be bent upon the tibiæ, the mandibles are generally salient and flattened or not thick, and the præsternum is more dilated anteriorly.

In the SILPHALES we find five distinct joints in all the tarsi, and the mandibles terminate in an entire point without fissure or emargination.[6] The antennæ terminate in a club which is generally perfoliated, and composed of four or five articulations. The internal side of the maxillæ in some is furnished with a horny tooth. The anterior tarsi are frequently dilated in the males, and the exterior margin of the elytra of the greater number is marked by a groove with an obvious border. This tribe is composed of the genus SILPHA of Linnæus.

In the genus NECROPHORUS, Fab. so named from νεκρος, *a carcass*, and φορεω, *I carry* (Plate CCXXIII. fig. 21), the antennæ, scarcely longer than the head, terminate abruptly in an almost globular club of four joints, the first of which is long, and the second much shorter than the third. The body forms nearly a parallelopiped; the thorax is widest anteriorly; all the tibiæ are strong, widened at the extremity, and terminated by strong spurs; the elytra are truncated at right angles. The maxillæ are destitute of a corneous claw.

This important and well-marked genus was first defined by Fabricius. Linnæus had placed the species of which it is composed with the Silphæ, while Scopoli and Geoffroy combined them with the genus Dermestes. The most marked peculiarity in their manners consists in their habit of interring small animals, such as mice and moles, for the purpose of depositing their eggs in their decaying carcass. To effect this operation, they remove the earth from beneath the dead body, which sinks into the hollow, and is afterwards covered with the looser soil of the excavation. Their sense of smell, like that of many other insects, is extremely delicate, and no sooner has any of the smaller quadrupeds perished, than one or more of these grave-diggers make their appearance, and in a few hours the corpse is interred. The larvæ are of a lengthened form, of a greyish-white colour, with a brown head. Their bodies are composed of twelve rings, furnished on their anterior and superior portion with a small scaly plate or shield, of a ferruginous brown colour; the shields of the last segments are provided with small elevated points. The head is hard, scaly, and furnished with strong cutting mandibles. The feet are six in number, very short, and attached to the first three segments of the body. When these larvæ have attained to their final term of increase, they descend, it is said, fully a foot beneath the surface, and, forming an oval chamber, the walls of which are strengthened by a coating of a gluey liquid, they assume the nympha state. The perfect insect makes its appearance in the course of three or four weeks. There are seven species of this genus in Britain. Dejean possesses twenty-five. They are all of considerable size, and are chiefly from Europe and North America. We have received a specimen from Persia.[1] *N. vestigator* is black, the club of the antennæ, external margin of the elytra, and two transverse bands, orange yellow. *N. humator*, the most common species in Scotland, is a shining black, with the club of the antennæ ferruginous. Neither *N. mortuorum* nor *N. vespillo* (the species here figured) are very common in Scotland.

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[1] *Annales des Sciences Nat.* Octob. 1824.

[2] *Règne Animal*, t. iv. p. 491.

[3] *Ibid.* Juil. 1825.

[4] The generic name is supposed to be derived from *Histrio*, a word of Tuscan or Etruscan root, signifying an actor, and was probably bestowed in consequence of their instinctive propensity to simulate death when handled.

[5] For the further divisions of this tribe, see Paykul's *Monographia Histeroideum*; and Leach's *Zoological Miscellany*, vol. iii.

[6] In *Sphærites*, dentations are sometimes found on the internal side.

In Necrodes[2] of Wilkin (Plate CCXXIII. fig. 23) the antennæ are obviously longer than the head, and terminated by an elongated club of five joints, the second of which is larger than the third. Their body is oblong oval, the thorax almost orbicular, widest in the middle. The tibiæ are narrow, elongated, slightly enlarged at the end, and terminated by two ordinary spurs. The elytra are obliquely truncated. We have probably not more than one species in Britain, *N. littoralis* (the species figured), which is black, depressed, and oblong, with the thin terminal joints of the antennæ orange. It occurs on the seashore and the banks of rivers, beneath sea-weed, carrion, &c. and is found on the continent of Europe, along with *N. simplicipes*. The others occur in North and South America, New Holland, and Java.

In the genus Silpha[3] the body is almost shield-shaped and depressed, or but slightly elevated. The thorax is semicircular, truncated, or very obtuse before; the exterior margin of the elytra strongly recurved and guttered; the palpi filiform, with the last article almost cylindrical, and in many terminated by a point. Most of these insects feed on carrion, and thus contribute to the more speedy disappearance of putrid effluvia. Some climb upon plants, particularly the stems of wheat and other grain, where they find small *Helices*, on which they prey. Others dwell on trees, and feed on caterpillars.

The genus was originally of great extent, but has been much modified and circumscribed by Fabricius, Dejean, Latreille, Leach, and others. The species which it now contains resemble their congeners in being of an essentially carnivorous nature—preferring animal substances in a state of putrescence to fresher food. They exhale a disagreeable odour, and, when seized, a thick and dark coloured liquid exudes from their bodies. The larvæ resemble the perfect insects in their habits. They consist of twelve segments, of which the sides are terminated by sharp angles, the terminal segment being furnished with two conical appendages; the head is small, and bears a pair of tri-articulate filiform antennæ, and two strong maxillæ. Like the preceding genus, they undergo their metamorphoses under ground. The species are pretty extensively distributed over the earth, and are rather numerous. Dejean enumerates thirty-four species in his Catalogue, which, however, includes under the generic name of Silpha the genera *Oiceoptoma* and *Phosphuga* of Dr Leach. Of the restricted genus we have not more than eight British species. Most of these are deep black or dark brown. One of the most ornamental is *S. quadripunctata* (Plate CCXXIII. fig. 24), of which the margins of the thorax and the elytra are pale-yellow, the latter with two round black spots on each. We took this rare Scottish insect some years ago near Currie, in the vicinity of Edinburgh. It has since been brought to us from Loch Tay by Dr Greville. It is more frequent in England, where it frequents oak woods for the purpose of preying on lepidopterous larvæ.

Tribe 4th, Scaphidites.

In these the mandibles are cleft or bidentated at the extremity. The tarsi are composed of five very distinct and entire joints. The body is oval, narrowed at either end, arcuated or convex above, and thick in the middle. The head is low, and received posteriorly into a trapezoidal thorax, slightly bordered, broadest behind. The antennæ are generally as long at least as the head and thorax, and are terminated by an elongated mass of five articles. The terminal joint of the palpi is conical. The legs are slender and elongated. With the exception of the *Cholevæ*, the tarsi are nearly the same in both sexes.

In this tribe we place the genera Scaphidium[4] of Olivier, and Choleva of Spence;[5] of the former, *S. maculatum* is the only British species,—the rest inhabiting North and South America, and some of the continental countries of Europe. Of the latter, Mr Spence has described eighteen British species, arranged in three sections, of which some of the constituent parts are referable to the genus *Ptomophagus*[6] of Illiger and Knock, to *Luperus*[7] of Frœlich, and *Catops* of Fabricius and Paykul. Only two or three of Mr Spence's species belong to the genus *Choleva* in its present restricted form.

Tribe 5th, Nitidulariæ.

The Nitidulariæ approach the Silphales in their scutiform and bordered body, but the mandibles are bifid or notched at their extremity; the tarsi seem to consist of only four joints, the first and last, in some, being only visible beneath, where they form but a slight projection,—in others the penultimate is extremely small, in the form of a knot, inclosed within the lobes of the preceding. The club of the antennæ is always perfoliate, of three or two joints, and is usually short or but slightly elongated. The palpi are short and filiform, or somewhat thickest at the extremity. The elytra in several are short or truncated. The legs are but slightly elongated, and their tibiæ frequently widened at the end; the tarsi are furnished with hairs or pellets. These insects are of various habits, according to the species. They occur on flowers, in mushrooms, beneath the bark of trees, and even on putrid meat. This tribe is composed of the genus Nitidula, as subdivided into Colobicus, Thymalus, Ips, Nitidula (proper) (Plate CCXXIII. fig. 25), Cercus, and Byturus.

In the restricted genus Nitidula,[8] the antennæ are short, abruptly clavate, the radical joint large, thick, and somewhat orbicular, the third above one half longer than the fourth, the three last forming a club. Nearly thirty species occur in Britain. Many others are found in Europe and America.

Tribe 6th, Engidites.

These resemble the preceding in the emargination of the extremity of the mandibles, which however project but slightly, and that laterally, beyond the labrum. Their body is oval or elliptical, with the anterior extremity of the head a little advanced in an obtuse or truncated point.

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[1] For notices of their anatomical structure, see Dufour, in *Ann. des Sciences Nat.* for October 1824 and July 1825.

[2] Probably from *νεκρωδης, cadaverous.*

[3] The word *Silpha*, derived from a Hebrew root, occurs in Aristotle, and appears to have been sometimes used by that author to signify a *cockroach.*

[4] From *Σκαφη, a boat*, and *ιδεα, form.*

[5] *Linn. Trans.* vol. xi.

[6] From *πτωμα, a carcass*, and *φαγω, I eat.*

[7] From *λυπερος, troublesome.*

[8] From *nitidus*, shining, or bright.

The tarsi consist of five distinct joints, entire, and at most only slightly pilose beneath, the penultimate being somewhat shorter than the preceding joint. The antennæ terminate in a perfoliate club of three articulations. The elytra completely cover the abdomen, and the palpi are somewhat thickened at the extremity. Some very minute species live in the interior of houses, and are frequently found on window-sashes. They constitute the genus DACNE, divisible into, 1*st*, *Dacne* proper (*Engis*, Fab. *Erotylus*, Oliv.), in which the antennæ terminate abruptly in a rather large, orbicular, or ovoid and compressed club, composed of crowded articulations, of which the central one at least is much wider than long, and the third longer than that which precedes and follows; the centre of the posterior margin of the thorax is dilated behind or lobed, and the upper extremity of the mentum is advanced, and terminated in a truncated or bidentated point: 2*d*, *Cryptophagus*,[1] Herbst, Lat. (*Dermestes*, Linn. *Ips*, Oliv. *Antherophagus*, Knock), in which the antennæ are moniliform, with the second article as large or larger than the preceding, and terminate in a less abrupt and narrow club than in *Dacne*, and with intervals between its segments. This is a pretty extensive genus, occurring in various parts of the world, but chiefly in European countries. We have fourteen species in Britain.

In Latreille's arrangement (*Règne Animal*, t. iv. p. 508) we now come to certain tribes in which the præsternum is frequently dilated anteriorly in the manner of a chin-cloth (*mentonnière*), and which differ from the preceding in their legs being more or less contractile. The tarsi may be free, but the tibiæ, at least, are folded upon the thighs. The mandibles are short, usually thick, and dentated. The body is ovoid, thick, and furnished with deciduous scales or hairs of various colours. The antennæ are generally straight, and shorter than the head and thorax. The head is sunk into the thorax as far as the eyes. The thorax itself is but slightly if at all bordered; it is trapezoidal, and wider posteriorly, the middle of the posterior margin being frequently somewhat prolonged or lobate. The larvæ are pilose, and dwell for the greater part on the skins or carcasses of animals. They are hurtful in museums. Those in which the legs are not completely retractile, the tarsi being always free, and the tibiæ lengthened and narrow, form

TRIBE 7TH, DERMESTINI.

In DERMESTES proper (so called from *δεϱμα*, *skin*, and *εσθεω*, *to eat* or *consume*) the antennæ are shorter than the thorax, the radical joint large and ovate, the seven following short and slender, the remaining three forming an ovate compressed club, of which the two lower joints are somewhat dilated in the inner side, the terminal being smaller and rounded. They are not received in a particular groove beneath the thorax. *D. lardarius* (Plate CCXXIII. fig. 27) is black, pubescent, the elytra with a broad cinereous band across the base, in which are three brownish or black spots. In ATTAGENUS the club of the antennæ is proportionlly very large, almost serrated, and composed of three articles, of which the first and last, especially in the males, are the largest. The body is ovoid, short, slightly convex. The terminal article of the maxillary palpi is large and ovoid. In ANTHRENUS[2] the club of the antennæ is more solid than perfoliate, and is in the form of a reversed cone, and lodged in a short cavity, hollowed beneath the anterior angles of the thorax. In the larva state these insects live on dried animal matters, particularly on the contents of entomological cabinets. In that condition they are oval, and furnished with hairs, some of which are dentated; they form aigrettes or tufts, of which the hinder are prolonged in the form of a tail. In the perfect state they are found among flowers. Other genera, such as *Limnichus* of Ziegler, *Trogoderma* and *Globicornis*, Lat., pertain to this tribe.

TRIBE 8TH, BYRRHII.

This tribe is composed principally of the genus *Byrrhus* of Linn., and differs from the preceding in its feet being entirely contractile, the tibiæ being susceptible of being bent upon the thighs, and the tarsi upon the tibiæ, so that the species, when their limbs are thus contracted, appear inanimate and without legs. The latter are usually broad and compressed. The body is short and convex.

In NOSODENDRON, Lat. (of which we have one British example, *N. fasciculare*), the mentum is entirely exposed, large, and buckler-shaped. In BYRRHUS proper the mentum is of ordinary dimensions, and as it were interlocked, at least partially, by the præsternum, of which the anterior portion is dilated. The larvæ of these insects have been studied by M. Wadouer. Their heads are large, their bodies narrow and elongated, with the two terminal segments more extended than the others; the first, or that of the prothorax, presents superiorly a large corneous plate. The genus was confounded by Degeer with *Dermestes*, and with *Cistela* by Geoffroy. The species occur in fields, woods, and sandy places. They are not unfrequent by the side of highways, and although they can fly with facility when they choose, they rarely exercise that faculty. When handled or even approached, they apply their legs and antennæ so close to the body as to exhibit the appearance of a little ball, and in that state they simulate death with great perseverance. Of eight or nine species found in Britain, we shall here name only *B. æneus*, an interesting species, lately added to the British Fauna by the Rev. James Duncan. It is oblong-ovate, brassy green above, scutellum whitish, the elytra irregularly punctured, and without striæ. It was found in an open part of a wood near Newbattle House in Mid-Lothian. It has since occurred under stones on Musselburgh Links, has been taken in Dumfriesshire, and was met with by Dr Greville in considerable numbers near the ferry of Kylestroem in Sutherland. There are thirty-three species in Dejean's collection.

SECTION 2*d*. The CLAVICORNES of this section, although forming a good natural group, can only be characterized by the assemblage of several features. Some which are nearest to the PALPICORNES have antennæ of only nine or even six joints. Others have ten or eleven joints to these organs, which are sometimes scarcely longer than the head, and from the third joint form an almost cylindrical or fusiform club, arcuated and somewhat serrated; sometimes nearly filiform, and as long as the head and thorax. In this case, as well as among most of the other genera of the same division, the tarsi are terminated by a large joint, with two strong hooks at the end. In certain genera, such as *Heterocerus* and *Georyssus*, these parts consist of only four articulations. The form of the body in this section is generally ovoid, with the head sunk up to the eyes in a trapezoidal thorax laterally bordered, and terminated posteriorly by acute angles. The præsternum is dilated posteriorly (the Potamophili excepted), and the legs are imperfectly contractile. They usually occur in water, beneath stones by river sides, or in mud. They form two tribes.

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[1] From *κϱυπτος*, *hidden*, and *φαγος*, *eating*.

[2] Ανθϱηνη is the ancient name of an insect which dwelt among flowers,—a kind of bee.

TRIBE 1ST, ACANTHOPODA.[1]

Remarkable for their broadish flattened legs, armed exteriorly with spines. The tarsi are short, of four articulations,[2] the hooks of ordinary size. The body is depressed, and the præsternum dilated. The antennæ are rather longer than the head, arcuated, and composed of eleven joints, of which the last six constitute an almost cylindrical and slightly serrated club, the second being short and not dilated. This tribe is composed of the single genus HETEROCERUS[3] of Bosc (Plate CCXXIII. fig. 26).

TRIBE 2D, MACRODACTYLA.[4]

Here are included such of the Clavicornes as have simple narrow tibiæ and lengthened tarsi, all composed, except in Georyssus, of five articulations, the last of which is large, with strong terminal hooks. The body is thick or convex,—the thorax less rounded, and usually terminated on both sides by acute angles.

The type of this tribe is formed by the genus *Dryops* of Olivier—*Parnus*, Fab. We here place the genus ELMIS,[5] of which the species, pretty frequent in Britain, occur in water, beneath stones, or on the leaves of water-lilies. In PARNUS proper (*Dryops*, Lat. Oliv.) the antennæ, shorter than the head, are lodged in a small cavity beneath the eyes, the second joint being compressed and much produced,—concave for the reception of the remaining joints, which form a serrated mass attached by a small peduncle near the base. *P. prolificornis* is oblong, olive brown, villose, with the elytra thickly punctured, and obscurely striated towards the sides and apex. It occurs in moist places by the sides of ponds and marshes, not unfrequent during spring. Here are also placed the genera *Potamophilus* of Germar, *Macronychus* of Müller, and *Georyssus* of Latreille.

FAMILY V.—PALPICORNES.

In this family, as in the preceding, the antennæ are terminated by a kind of club, usually perfoliate, but composed at most of only nine articulations, and inserted beneath the advanced and lateral margins of the head, and scarcely longer than it and the maxillary palpi,—frequently even shorter than these last-named organs. The mentum is large and buckler-shaped. The body in this family is generally ovoid or hemispherical, and arched or convex. The feet in most of the genera are formed for swimming, and these present either four articulations to the tarsi, or five, of which the first is much shorter than the second: the whole are entire.

TRIBE 1ST, HYDROPHILII.

Feet fit for swimming. First article of the tarsi much shorter than the others. Maxillæ entirely corneous. Of this tribe (genus *Hydrophilus* of Geoffroy) Linnæus formed only a division of his genus Dytiscus. Their anatomical structure however differs in many important particulars from that of the true Dytisci. The digestive canal, which is four or five times as long as the body, presents a strong analogy, both in its length and texture, to that of the Lamellicornes, and differs from that of the Carnivora except as regards the biliary vessels. We perceive neither the swimming bladder nor the excrementitial apparatus, such as these exist among the Hydrocanthari. In the females only, the latter is replaced by secreting organs fitted for the formation of a cocoon to contain the eggs. The sexual organs of the male bear a great resemblance to those of the preceding family. These and other considerations have induced M. Latreille to place them here. The species are more convex in their general forms than the Dytiscidæ, and their antennæ are dissimilar; but in many of their instincts and habits of life, and in their general transformations, they bear a resemblance to that group. The largest water insect of Great Britain (*Hydrophilus piceus*), which we have failed as yet to discover in Scotland, belongs to this division. Many species are also extremely minute.

In the genus HELOPHORUS of Leach (from ἕλος, *a marsh*, and φορεω, *I penetrate*) the antennæ are shorter than the head, the first joint is the longest, robust, and slightly curved, the second shorter than the first, the three following minute, the last four forming the club. *H. aquaticus* (Plate CCXXIII. fig. 29) abounds in almost every pond. It is almost always found covered with mud, in such an ingenious manner that, when feeding in its little pool, it is with difficulty distinguished from the subjacent soil, either by its natural enemies, or the no less dangerous eye of the practical entomologist. *H. granularis* is more frequently found upon the wing in situations remote from water. In HYDROCHUS of Germar (from ὕδωρ, *water*, and οικεω, *to inhabit*) the general form is narrower and more elongated, the thorax like a lengthened square, and the eyes prominent. *H. brevis*, a rather scarce species, occurs in the Edinburgh district in ditches near Craigcrook, and in the Braid marshes. As allied to the preceding genera we may here name ENICOCERUS of Stephens (so called from ενικος, *singular*, and κερας, *horn*). The antennæ are as long as the head, the basal joint long, curved, slightly geniculate at the base, the second ovate-truncate, three or four following very minute and obscure, the last five of nearly equal thickness, penultimate cup-shaped, terminal orbicular. *E. viridiæneus*, of a brassy green, thorax with an oblique groove near each of the hinder angles, and two foveæ in front, the legs piceous. Although a newly described insect, it does not seem at all scarce in Scotland, where it occurs beneath small stones by the margins of water, or imbedded among mud and confervæ. In the genus SPERCHÆUS, Fab. the antennæ have only six joints, and the clypeus is emarginate. In HYDROPHILUS,[6] properly so called, of Leach, the tarsi are identical in both sexes and not dilated, the pectoral spine terminates with the præsternum, and the scutellum is proportionally small. *H. caraboides* is the only British species. The genus HYDROUS of the last-named author[7] (*Hydrophilus*, Lat.) is characterized by the great extension backwards of the sharp-pointed sternal spine, and by the triangular-shaped dilatation of the last article of the two anterior tarsi of the males. The scutellum is large. *H. piceus* (Plate CCXXIII. fig. 28), the only British species, is one of the largest of the European Coleoptera. It measures above an inch and a half in length, is of an oval form, a blackish-brown colour, with a polished or shining surface. The club of the antennæ is partly reddish. A few slight striæ are visible on the elytra, of which the posterior extremity is rounded posteriorly, and prolonged to a small tooth at the inner angle. This fine insect flies well and swims swiftly, but is inefficient as a pedestrian. When held loosely in the hand it sometimes inflicts a wound with the point of the sternum. The female constructs an ovoid cocoon, arcuated, and of a brown colour. Its exterior tissue is composed of a gummy paste, at first somewhat fluid, which soon hardening, becomes impenetrable by water. The eggs which it envelopes are symmetrically disposed, and kept in their position by a sort of whitish down. These cocoons float in the water.[1] The larva is depressed, blackish, and rugose; the head reddish brown, smooth, round, and capable of being drawn backwards. This peculiar faculty gives it the power of seizing whatever small shells or other living prey it may perceive floating on the surface. Its back serves it as a kind of table, on which it bruises its prey. The bodies of these predaceous larvæ become very flaccid as soon as they are caught. They swim with facility, and are provided beneath the anus with two fleshy appendages, which serve to maintain them at the surface of the water when they ascend to breathe.[2] They are called on the continent *vers-assassins*, on account of their greedy and ferocious nature. They become more herbivorous in the perfect state.

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[1] From ακανθα, *a thorn* or *spine*, and ποῦς, *foot*.

[2] According to the accurate Gyllenhal, there are actually five, the first being small and oblique. (*Insecta Suecica*, t. i. p. 138.)

[3] From ἕτερος, *different*, and κερας, *horn*.

[4] From μακρος, *long*, and δακτυλος, *finger*.

[5] The name is applied by Galen to a species of intestinal worm.

[6] From ὕδωρ, *water*, and φιλος, *a lover*.

[7] *Zoological Miscellany*, vol. iii. p. 94.

In LIMNEBIUS of Leach (from λιμνη, *a marsh*, and βιος, *life*), the antennæ are short, slender, the club six-jointed; the maxillary palpi longer than the antennæ, with the terminal article shorter than the preceding, and cylindrical. In this tribe are likewise included the genera *Hydrobius* and *Berosus*.

TRIBE 2D, SPHÆRODIOTA.

These Palpicornes differ from the preceding in being terrestrial. Their tarsi consist of five distinct articulations, of which the first is at least as long as the following. The maxillary palpi are shorter than the antennæ, with the third joint larger, inflated, and in the form of a reversed cone. The maxillary lobes are membranous. The body in this tribe is almost hemispherical, with the præsternum prolonged to a posterior point, and the tibiæ spinous, the anterior being palmated or digitated in the larger species. The antennæ are always composed of nine articles, or simply of eight, if we regard the terminal one as an appendage of the preceding. The genera are CERCYON of Leach, and SPHÆRIDIUM[3] of Fabricius (Plate CCXXIII. fig. 30). The former is abundant in Britain, where we find about sixty species, many of which occur in Scotland.[4] Few are as yet ascertained to inhabit extra-European countries, although one or two occur in North and South America. All the species of this tribe are of small size. They usually occur in cow-dung, and excrementitious matter. Some are found on the margins of water.

FAMILY VI.—LAMELLICORNES.[5]

This is the last family of the pentamerous Coleoptera, and one of the most remarkable of the order,—whether we consider the great size of many species, the singularly varied forms of their head and thorax, or the richness of the metallic colouring with which the vegetable-eating kinds are frequently adorned.

The antennæ, inserted in a deep groove beneath the lateral margin of the head, are always short, and composed generally of nine or ten articulations; they are always terminated in a club or mass, which usually consists of three joints, expanded in the form of thinnish plates or leaves, disposed in various ways,—like the spokes of a fan, the leaves of a book, the teeth of a comb, or a series of funnels placed above and within each other. The body is generally ovoid or oval, and thick. The exterior edge of the two anterior tibiæ are toothed, and the articles of the tarsi, with the exception of certain males, are entire, and without brush or pellet beneath. The anterior extremity of the head is advanced and dilated in the form of a clypeus or epistoma. The mentum is usually large, covering the ligula, or incorporated with it, and bearing the palpi. The mandibles of many are membranous, a character scarcely if at all to be observed in any other Coleoptera. The males are frequently very different from the females, being distinguished by horn-like elevations on the head and thorax, and by the greater size of the mandibles. Linnæus indeed founded the sections of his great genus Scarabæus in accordance with these peculiar projections, while Scopoli assumed the spines or teeth of the fore-legs as the distinguishing characteristic of his subdivisions. The latter author likewise proposed two other methods, one of which regards the number of articulations in the clava of the antennæ, and the other takes into consideration the varying manners of the insects themselves. The former of these is extremely defective, the second is chiefly deserving of consideration as exhibiting the first attempt ever made towards a natural arrangement of these insects. They are divided into *Anthophylli*, *Phyllophagi*, and *Stercorei*.

Degeer was the first to avail himself of the improvements indicated by Scopoli, while at the same time he avoided his principal imperfections. He arranged the Scarabæi into three families, as follows: 1*st*, *Scarabées de terre*; 2*d*, *Scarabées des arbres*; 3*d*, *Scarabées des fleurs*. Oryctes and Trox were no longer regarded as phyllophagous insects.

Geoffroy separated from Scarabæus of Linnæus the exscutellated species under the name of *Copris*, and Scopoli's genus Lucanus under the name of *Platycerus*. The institution of the genus Copris was certainly an improvement, although it was founded on such defective characters, that coprophagous insects, such as the family Geotrupini of Latreille, were included in the same genus with Cetonia, from which they might have been perceived to be distinct so soon as the necessity was admitted of carrying the investigation among the *Lamellicornes* somewhat beyond that first affinity—the form of the antennæ.

At a still later period Fabricius further improved upon the heterogeneous composition of Geoffroy's genus Scarabæus, by taking from it the genera *Trox*, *Melolontha*, *Cetonia*, and *Trichius*. But the re-union of Geoffroy's genus Copris with Scarabæus was a retrograde step which the entomologist of Keil afterwards corrected in a supplementary work. The connection, however, between the insects afterwards named *Geotrupes* by Latreille and the genus Copris of Geoffroy, was so far re-established by the formation of the Fabrician genus Scarabæus.

Olivier adopted the genus Scarabæus of Fabricius, with all his other genera except Trichius, and divided it into

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[1] For a detailed and accurate account of the structure and transformations of this insect, see a posthumous work of the celebrated Lyonnet, lately published under the title of *Recherches sur l'Anatomie et les Metamorphoses de differentes espèces d'Insectes.*

[2] *Annales du Museum d'Hist. Nat.* t. xiv. p. 441.

[3] From Σφαίρηδιον, *globe-shaped.*

[4] See *Ent. Ed.* p. 139.

[5] From *lamella*, a little plate, and *cornu*, a horn, in allusion to the structure of the club of the antennæ.

Coleoptera Pentamera.

the following sections: 1*st*, Those furnished with mandibles, but unprovided with a labium; 2*d*, those furnished with mandibles and a labium; 3*d*, those which have neither mandibles nor labium. The three groups just mentioned are characterized by Mr Macleay as strictly natural.[1]

This important family, in the system of Latreille, seems to include all those insects classed by Linnæus in the old genera *Scarabæus* and *Lucanus*. The lamellicorn tribes, indeed, include a very numerous assemblage, many of which, especially such as feed on flowers and living vegetation (called *Thalerophaga* by Macleay), are remarkable alike for beauty of form and splendour of colour. Most of those, however, which feed on decomposed vegetables, or excrementitious substances, are usually of a more uniform black or brownish hue. But even the coprophagous kinds sometimes surprise us by their beauty, and present a singular contrast when disentangled from their repulsive habitations. They are all winged insects, although for the most part rather dull and heavy in their movements.

The larvæ are long, semi-cylindrical, soft, of a whitish colour, and divided into twelve rings or segments. The head, of a harder consistence, is armed with strong mandibles. The feet are six in number, and squamous or of a scaly texture. On each side of the body there are nine stigmatic openings. The posterior extremity is the most bulky; it is rounded and almost always curved inwards, in such a manner as to prevent the larva from extending itself in a straight line. Its motions are consequently slow and awkward, and when crawling on the surface it frequently rolls over or falls on one side. The nympha or intermediate state is in some instances not assumed till after the lapse of several years. Immediately preceding the assumption of that state the larva protects itself by means of a cocoon of an oval form, composed of earth and the gnawed fragments of other materials, agglutinated by a viscous secretion which exudes from its body. These larvæ seek their food in the dung of cattle, in tan pits, in gardens where rich vegetable mould occurs, and among the roots of plants. In regard to their interior structure, it has been observed that the nervous system, when studied in the different stages of life, presents a considerable dissimilarity. The ganglions are less numerous, and approximate more to each other, when the insect has reached the term of its final transformation; and the two posterior ganglia throw out numerous filaments disposed in a somewhat radiated form. In the larva the trachea is elastic, but simply tubular in the perfect insect. The structure of the eye in most of the lamellicorn beetles exhibits characters analogous to those of the Tenebrionites, the Blattæ, and other lucifugous or light-shunning species.

The alimentary canal is of great length, especially among the coprophagous kinds; and the chylific ventricle is beset with papillæ, which, according to the investigations of M. Dufour, serve as the receptacles of the alimentary fluids. The biliary vessels resemble those of the carnivorous Coleoptera in number and position, but they differ in being of greater length and much more slender. Latreille divides this important family into two tribes.

TRIBE 1ST, SCARABÆIDES.[2]

These correspond to the unrestricted genus *Scarabæus* of Linn. Their antennæ are terminated by a foliaceous club, generally capable of being alternately closed or expanded; or are composed of joints that fit into each other, either in the form of a reversed cone, or nearly globular. The mandibles are of identical form, or nearly so, in both sexes; but the head and thorax of the males frequently exhibit projections or peculiar forms. The antennæ in the latter sex are frequently more fully developed than in the females. The alimentary tube in these insects is generally much longer than that of the following tribe, and the œsophagus is proportionally shorter. But it is chiefly by the genital system of the males that the Scarabæides are distinguished, not only from the tribe with which they are conjoined, but from all other pentamerous Coleoptera. The larvæ have a cylindrical stomach surrounded by three ranges of small cæca, the small intestine very short, the colon extremely thick and turgid, and the rectum of moderate size. A prodigious accession of fine typical forms has been received of late years by this division of Entomology, far beyond what we are able to indicate in this work.[3] We shall, however, notice the most important and remarkable genera, and illustrate many of these by means of the plates connected with this department of the Encyclopædia.

The following sections are established on the consideration of the masticating organs, the antennæ, and the habits, and have been confirmed by the anatomical researches of M. Dufour.

SECTION 1ST, COPROPHAGI.[4]

In some of these the antennæ are formed of nine, in others of only eight articulations; the three terminal ones forming the club. The labrum and mandibles are membranous and concealed. The terminal lobe of the maxillæ is also of the same consistence, broad and arcuated at the upper margin, and curved inwards. The terminal article of the maxillary palpi is always the largest of all, nearly oval or almost cylindrical; but that of the labial palpi is almost always more slender than the preceding, or very small. Behind each of these latter palpi is a membranous projection, in the form of a ligula. The mentum is emarginate. The sternum presents no particular projections, and the hooks of the tarsi are always simple. The anterior tarsi are frequently wanting in certain species, either naturally or because they are deciduous. The extent of the alimentary canal is always very great, occasionally (as in *Copris lunaris*) even ten or twelve times the length of the body. The chylific ventricle occupies the greater portion; it is beset with papillæ, conoid or in the form of nails, folded on itself, and maintained in that state of agglomeration by numerous tracheal bridles. The intestine is filiform, but terminates in an enlargement. "Les testicules des coprophages disséqués par M. Dufour, lui ont paru composés de six capsules spermatiques, orbiculaires, un peu deprimées ordinairement réunies, par des trachées, en un paquet, portées chacune sur un pédicule tubuleux, assez long, et qui aboutit à un canal déférent de peu de longueur. Il n'y a qu'une paire de vesicules séminales; elles sont filiformes, très longues et fort repliées."[1] Our present section corresponds to the third division of the genus Scarabæus of Olivier (*Copris*), with the addition of some other Scarabæi (*Aphodii*) of that author.

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[1] *Hor. Ent.* p. 17.

[2] The *Scarabæidæ*, as restricted by Macleay, are chiefly tropical forms, that is, the species in the warmer regions of the earth are to those from beyond the tropics nearly as five to one. Out of 450 species and upwards, in the collection of Mr Macleay senior, only nine are natives of England, and of these eight are *Onthophagi*.

[3] Comte Dejean informs us that his collection now contains 2060 species of *Lamellicornes*, among which he has found himself under the necessity of establishing 76 new genera.

[4] From Κοπρος, *dung*, and φαγος, *eating*.

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> In some the intermediate pair of legs are much more remote from each other at the base than the rest; the labial palpi are hairy, with the terminal articulation much smaller than the others, or even indistinct; the scutellum is either null or extremely small.

Coprophagi of this division, peculiar to the eastern continent, with a rounded body, usually depressed above, or but slightly convex, similar or differing little in the sexes, and without horns; the antennæ of nine joints, terminated by a foliated club; without either scutellum or a sutural hiatus indicating its place; the four posterior tibiæ, usually furnished, as well as the tarsi, with ciliated or hairy fringes, and slender, elongated, not dilated at the extremity, or but slightly so, truncated obliquely, and terminated by a single strong-pointed spur; with the epistoma more or less dentated;—these form the genus ATEUCHUS[2] of Weber and Fabricius. (Plate CCXXIV. figs. 1 and 2.)

The above genus, however, has been since restricted to such species as have the exterior margin of the elytra straight or unemarginated, and without a sinus, near the base, leaving exposed the corresponding portion of the upper margin of the abdomen. The tibiæ and tarsi of the last four legs are furnished with long hairs; the first four articles of the tarsi are generally longer than the others. The first joint of the labial palpi is almost cylindrical, or in the form of a reversed cone. The epistoma is generally divided into three lobes or festoons, and its contour presents six teeth. The *Ateuchi* form the genus *Scarabæus* of Macleay.[3] These insects deposit their ova in dung, which they form into balls, and roll along with their hind legs till they find a hole adapted to receive them, or a softish soil in which they may be buried. Two species were worshipped by the ancient Egyptians, and form a noted and conspicuous feature in the hieroglyphical system of that mysterious nation. We still find them sculptured on their monuments, in various positions, and sometimes of gigantic size. They were also formed into separate figures, as seals and amulets, composed of gold and other precious materials, and hung around the necks of the living, or buried along with their famous mummies. The insect itself in the natural state is also sometimes found in their gaudy coffins.

The *Ateuchus sacer* (Plate CCXXIV. fig. 2) occurs not only in Egypt, where it formed an object of superstitious worship, but over a great portion of the south of Europe. It is also found in the western regions of Asia. Another species, discovered in Sennaar by M. Caillaud, was, however, according to M. Latreille, the first to attract the notice of the Egyptians.[4] It is named *A. Egyptiorum* (ibid. fig. 1), and, instead of being black like the former, is green with a golden hue. The occiput also, instead of being bi-tuberculated, exhibits only a slight elongated eminence, which is smooth and shining.

In GYMNOPLEURUS of Illiger, the exterior sides of the elytra are strongly emarginate near the base. The four posterior tibiæ are in general simply ciliated, or furnished with small spines, and the last article of the tarsi is as long, if not longer, than all the preceding ones taken together. The first article of the labial palpi is dilated internally and almost triangular. There is a fossula on each side of the thorax.[5]

Other Coprophagi, nearly allied to the preceding, and likewise placed by Fabricius among the Ateuchi, are distinguished by the intermediate tibiæ, the extremities of which, as well as of the two hinder ones, are frequently clubbed or dilated, and present two spurs or spines. The epistoma in many has only four or two teeth. The first article of the labial palpi is always larger than the following, and dilated on the internal side. The third and last article is distinct. We shall here name only the genus SISYPHUS, which differs from the others in having only eight joints in the antennæ. The form of the abdomen is triangular, and the intermediate and hind legs are long and narrow, with the thighs clubbed.

In all the ensuing Coprophagi the intermediate and hind tibiæ are always dilated at their extremity, and almost in the form of a lengthened triangle; the intermediate pair terminate, like those of the preceding, in two strong spines; but the head or thorax, or both these parts, of the males, are distinguished by horns or marked projections. In several the last three articulations of the antennæ are semi-cupular, and concentrically fitted into each other. These insects are referable to the genera *Onitis* and *Copris* of Fabricius.

The genus ONTHOPHAGUS,[6] Lat. (ibid. fig. 3) (which, in common with ONITICELLUS of Dejean, has the third joint of the labial palpi small or indistinct, and the preceding larger than the first), exhibits a short body with a thickish thorax, broader than long, and semi-orbicular or nearly orbicular, but strongly emarginate or truncated in front. The head, and frequently the thorax also, is horned in the males. The scutellum is not apparent. Of this genus we have eight or ten species in Britain. Dejean's Catalogue contains 150. Some beautiful species of small size occur in Africa and the East Indies. They are likewise met with in New Holland, where they constitute the principal portion of the coprophagous beetles, which seem rare in that vast region, a circumstance attributed by Mr Macleay to the absence of all large herbivorous mammalia, except of the marsupial kind.

Two other genera, furnished with a scutellum or a sutural hiatus, with the anterior legs often deprived of or unprovided with tarsi, and frequently long, slender, and curved in the males, are distinguished from all other Coprophagi by the form of the club of the antennæ; its first joint (or the seventh of the whole, counting from the base) being sub-triagonal, and receiving within it the ensuing, of which the inner margin is shaped like a horse-shoe; the third or terminal article is in the form of a reversed cupula. The thorax is large, and usually exhibits two depressions near the middle of its posterior margin. In Onitis, Fab., the second article of the labial palpi is the largest of all; and the scutellum, though small and sunken, is yet visible. The anterior legs are generally long, slender, and curved in the males, and the tarsi are often absent. The thorax, with a few exceptions, is without horns. In Phanæus of Macleay (Copris, Onitis, Fab.), Plate CCXXIV. fig. 4, the first article of the labial palpi is the largest, and dilated on the inner side. A simple sutural void indicates the place of the scutellum. This genus is composed of large and beautiful species, chiefly from the equinoctial regions of the new world. The males differ greatly from the females in regard to the horn-like processes which frequently characterize the head and thorax of the former; but the respective length of the legs does not differ between the sexes, as in the preceding genus.

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[1] *Règne Animal*, t. iv. p. 531.

[2] Probably from α priv. and τευχος, *an instrument of war*, the head being unarmed.

[3] The genus Scarabæus of Macleay (Ateuchus of most modern authors) is proper to the ancient world. Of the forty-three species which compose its five types, as exposed in the *Horæ Eutomologicæ*, twenty-seven occur in Africa. The first type extends from the Atlantic Ocean to Thibet, and from Austria to the Cape of Good Hope. It contains the following species:—*S.* (HELIOCANTHARUS) *sacer*, *Dufresnii*, *pius*, *Bonelli*, *Hottentotus*, *impius*, *Lamarckii*, *Cuvieri*, *Sanctus*, *Palæmon*, *intricatus*, *puncticollis*, *Spencii*, *Degeeri*, *Savignii*, *morbillosus*, *laticollis*, *variolosus*, *semipunctatus*. Type second contains as yet only a single species, from the north of Africa, *S.* (MNEMATIUM) *Ritchii*. The third type seems confined to the south of Africa, and includes *S.* (PACHYSOMA) *Æsculapius* and *Hippocrates*. The existence of the fourth type is inferred upon general principles, and from an observed hiatus in the series of affinities, but has not yet been specially detected. The fifth type inhabits all that tract of country which extends from the Atlantic Ocean to the Chinese Sea, and from Paris to the Cape of Good Hope, and contains *S.* (GYMNOPLEURUS) *azureus*, *nitens*, *mundus*, *sinuatus*, *pilularius*, *Sturmii*, *atronitidus*, *flagellatus*, *humanus*, *Leei*, *Bufo*, *fulgidus*, *cærulescens*, *affinis*, *cyaneus*, *Kœnigii*, *granulatus*, *parvus*, *miliaris*, *spilotus*, *maculosus*.

[4] *Description des Insectes recueillis par M. Caillaud*, forming part of his *Voyage en Nubie*.

[5] For the other genera, see *Règne Animal*, t. iv. p. 405. Consult also *Hor. Ent.* p. 494.

[6] From ὀνθος, *dung*, and φαγος, *eating*.

The genus Copris[1] (Plate CCXXIV. fig. 5), as now restricted by Latreille, contains those species only the antennæ of which are terminated by a trifoliate club; the four anterior tibiæ strongly dilated and truncated at the extremity; both scutellum and hiatus wanting; the body thick, and differing on its upper surface in the sexes; and the labial palpi composed of three distinct joints, of which the first is the largest, almost cylindrical, and not dilated on the inner side. The largest species of this numerous genus (there are eighty-four in Dejean's collection, of which, however, scarcely half a dozen are European, and only one, *C. lunaris,* occurs in England) are indigenous to the warmer countries of Asia and Africa.[2] Many species are likewise native to the new world.

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In others the legs are inserted at equal distances from each other; the scutellum is distinct; the labial palpi smooth, or but slightly haired, with the third and terminal article larger, or at least longer, than the preceding.

In the genera of this subdivision of the Coprophagi the elytra entirely envelope the contour of the abdomen, to which they form as it were an arched covering,—a character by which they approach the ensuing section. They are, however, closely related, by the structure of their legs and antennæ, to the preceding genera; although the sexual differences are less pronounced or apparent, and frequently consist merely in small tubercles instead of horns. All the species are of small size, and some of them are among the most frequent of the British Lamellicornes. They constitute the family *Aphodiidæ* of the English entomologists. These insects are extensively distributed over the whole of the north temperate zone; and Mr Macleay has made out the proportion of tropical species to be to those from countries beyond the tropics as one to eight. According to the same authority, none have hitherto been brought from New Holland, although several occur at the Cape of Good Hope, which is nearly of the same south latitude. It is probable, however, that if the marine detritus of New Holland were properly searched, some insects at least approaching to *Psammodii* in habit would occur.[3]

Although these insects closely resemble each other in general structure, they yet differ rather widely in their modes of life. They are not all coprophagous, strictly speaking, for several prefer vegetable matter, for the most part marine, in a state of putrescence. We shall notice the two principal genera. In Aphodius,[4] Fab. (Plate CCXXIV. fig. 6), the last article of the maxillary palpi is cylindrical, and that of the labial more slender than the preceding. The maxillæ have no appendage, or corneous and dentated lobe, on the inner side. The species of this genus are slow of foot, but they fly with facility; and their appearance is interesting, as denoting the "ethereal mildness" of returning spring. They are common in cow pastures. We received the species figured on the plate referred to (*A. bipunctatus*) from the south of Russia. Above fifty species occur in Britain, and three times that number are known to naturalists. In *Psammodius*, Gyllenhal (so named from ψαμμωδης, sandy, in reference to the places of their most frequent occurrence), the last article of the palpi is almost oval, and longer and thicker than the others, and the internal lobe of the maxillæ is corneous, and divided into two dentations.

Section 2d, Arenicoli.

The groups of this section have one character in common with the two genera last mentioned, that the elytra entirely cover the posterior extremity of the abdomen; but their other features are distinctive. The labrum is coriaceous, and generally projects beyond the epistoma. The mandibles are corneous, and usually curved and salient. The terminal lobe of the maxillæ is straight, and not curved inwards. The third and last article of the labial palpi is always very distinct, and always at least as long as the preceding. With few exceptions, the antennæ consist of from ten to eleven articulations. Like the preceding insects, however, these also live in dung, beneath which they dig holes in the earth. Their principal period of flight is during the evening, after sunset. When touched they counterfeit death.

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In this subdivision the labium is terminated by two lobes or projecting ligulæ; the mandibles are generally salient and curved; the labrum is exposed in whole or in part; the antennæ, in the greater number, are composed of eleven articulations. The body is black or reddish, with the elytra smooth or simply striated. The males are generally distinguished from the females by horn-like projections and other external characters. They affect more especially excrementitial substances.

In the genera Ægialia of Lat. and Chiron (Plate CCXXIV. figs. 7 and 11) of Macleay, the antennæ are only nine jointed. In the latter their terminal club is rather semipectinated than foliated, and the species are placed by some with *Passalus.*

In the subsequent genera the antennæ are considered to consist of eleven joints, although the computation varies according to the view which may be adopted of the exact structure of the articulations. The genus Lethrus, Scopoli, is distinguished from all the others by the form of the antennal club, like a reversed cone, and composed of leaflets contorted into a kind of funnel, and fitted concentrically into each other; and by the mandibles, which are entirely dentated and serrated on their inner side, and present a corneous advancement underneath, especially in the males. *L. cephalotes* is said to be extremely injurious to cultivated grounds, where it attacks the scarcely visible buds and leaves of plants, cutting them cleanly off with its mandibles. It is hence called *Schneider* in Hungary, where it sometimes proves very hurtful to the vines. This species (there are only two or three others known) lives in holes in the earth, and fierce battles take place during the nuptial season between the males when aspiring to the favour of the gentler sex. The antennal club of the remaining Arenicoli is composed of ordinary-shaped leaflets, placed one on another like the leaves of a book. In Geotrupes of Lat. (Plate CCXXIV. figs. 9 and 10) named from γη, *the earth*, and τρυπαω, *to bore*, in reference to their excavating propensities, the club of the antennæ is oval or ovoid, and the edges of all the leaflets are perceptible even when the part is contracted. The labrum forms a transverse square, entire, or simply dentated. The mandibles are curved, greatly compressed, dentated at the extremity, and frequently sinuated on the inner side. The species are pretty numerous, and occur both in Europe and America. Some are common in Britain, especially *G. stercorarius*, a large black beetle, with brilliant metallic blue or purple reflections on the under surface, well known as "wheeling its drowsy flight" during fine evenings. We have often been amused by the different devices made use of by insects to deceive their enemies. While the Byrrhidæ, and several other tribes already alluded to, contract their limbs when alarmed, so as to give themselves the appearance of a little ball of inert matter in no way tempting to any insectivorous creature, the species above named pursues an opposite line of conduct, and sticks out its legs at full length, where it holds them perfectly still and rigid, so as to produce the same appearance as if it had been long deprived of life. It is thus supposed to deceive the cunning rook and other birds, which value it chiefly as a living prey.[1] In Bulboceras[2] of Kirby (Plate CCXXIV. figs. 12, 13, and 14), one of the mandibles is simple at the extremity, while the other is dentated. The genus is also distinguished from the preceding (in common with *Athyreus* and *Elephastomus* of Macleay) by having the club of the antennæ large, orbicular, or nearly globular, with its first and last leaflet, when the part is contracted, completely enveloping the tenth or intermediate, and forming for it a kind of box (see figs. 13 and 14).

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[1] From κοπρος, *dung.*

[2] The fine insect which, following the nomenclature of M. Fischer of Moscow (*Entomog. de la Russ.*), we have represented as an *Ateuchus* (see Plate CCXXIV. fig. 8), is, we understand, regarded by Latreille as belonging to the genus *Copris.*

[3] *Hor. Ent.* i. p. 58.

[4] From αφοδος, *dung.*

In *Hybosorus* and *Acanthocerus* (placed in different families, the former in *Geotrupidæ*, the latter in *Trogidæ*, by Macleay[3]), the antennæ consist, as in most of the subsequent Scarabæides, of ten articulations.

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In this our second subdivision of the Arenicoli, the antennæ, scarcely longer than the head, are composed of ten articulations, of which the first is large and hirsute. The ligula is entirely concealed by the mentum. The labrum and mandibles are but little exposed, and the latter are thick. The palpi are short, the mentum very hairy. The inner side of the maxillæ is armed with teeth. The body, of a cinereous or earthy hue, is rough or tuberculated on the upper surface. The head is inclined, and terminates in an angle or point. The thorax is short, transversal, without lateral borders, sinuated posteriorly, with the anterior angles advanced. The abdomen is large, arched, and covered with very hard elytra. The anterior legs are advanced, and their thighs cover as it were the lower surface of the head.

These insects form the genus Trox[4] of Fabricius and Olivier. They generally occur on sandy soils, and are supposed by Latreille to feed on the roots of plants. We suspect that our knowledge is still extremely vague regarding their habits of life and modes of transformation. It is certain that they are attracted by dried bones and other cadaverous remains, but it is difficult to determine whether this is owing to the peculiar colour, or the nature of the animal substance. Pallas observes, "sub cadaveribus æstivo ardore exsiccatis cum Histeribus et Dermestibus hospitatur;" but it by no means follows from that peculiarity of position that the insect partakes of the carcass, any more than that numerous other species which seek the secure covering of a rock or mass of stone, are in the habit of devouring these inorganic matters. We may further remark that the Troges are the only petalocerous insects among which we find an apterous species,—the *T. horridus* being destitute of wings. It forms the genus *Phoberus* of Macleay, and is worthy of consideration as probably destined, when its habits are better known, to throw some light, either by agreement or opposition, on the history of its congeners, and the value of the groups into which they have been divided. These in general are supposed to delight in cadaverous substances: all insects intended to live on animal matter, partially distributed and collected in masses, are provided with wings, which convey them rapidly (with the joint guidance of the sense of smell), to those decaying objects which they instinctively desire; but the species above named being destitute of wings, a doubt naturally arises as to the probability of its feeding, like its congeners, on dried cadaverous matter. It has been stated as an illustration of this point, that the genera *Silpha*, *Hister*, *Dermestes*, and other necrophagous kinds, are winged, whilst *Pimelia*, *Brachycerus*, &c. which, like *T. horridus*, frequent sandy deserts, are apterous,—a formation supposed to accord with the fact that the particles of which their food is composed are so universally spread over these arid plains as to obviate the necessity of any rapid or extended change of place.[5]

Section 3d, Xylophili,[6] Lat.

In these the scutellum is always distinct, and the elytra do not cover the posterior extremity of the abdomen. In several the hooks of the tarsi are unequal. The antennæ have always ten articulations, of which the last three form a foliated mass,—the central leaflet being never entirely concealed or inclosed by the others. The labrum is not projecting, and only its anterior part is exposed. The mandibles are entirely corneous, and laterally project beyond the head. The maxillæ are corneous, or of a solid texture, straight, and usually toothed. The ligula is covered by an ovoid or triangular mentum, narrowed and truncated at the extremity, where the angles are frequently dilated. All the legs are inserted at equal distances from each other.

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A first subdivision contains those genera in which the males are distinguished from the females by tubercles or horn-like projections on the head or thorax, and sometimes by a difference in the form of the latter part. The epistoma is small, triangular, and either pointed, truncated, or bidentated at the end. The labrum is almost always concealed. In some the maxillæ terminate by a simple coriaceous or crustaceous lobe, more or less hairy, and without teeth; in others they are entirely squamous or scaly, pointed, and provided with a small number of teeth, accompanied by hairs. The mentum is ovoid, or truncate-triangular. The chest exhibits no projection. The hooks of the tarsi are generally equal. The scutellum is small, or of medium size. The colours incline to black and brown.

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[1] *Ent. Edinensis*, p. 180.

[2] From βολϐος, *a bulb*, and κερας, *a horn*.

[3] See *Horæ Ent.* p. 62; *Ent. Ed.* p. 186; and *Règne Animal*, t. iv. p. 546.

[4] Τρωξ, from τρωλῶ, *I gnaw*.

[5] *Hor. Ent.* pp. 120 and 136.

[6] From Ξυλον, *wood*, and φιλος, *a lover*.

Of those genera in which the maxillæ are terminated by a coriaceous or crustaceous lobe without teeth, and simply hirsute or furnished with cilia, we shall adduce as an example ORYCTES[1] of Illiger (Plate CCXXIV. fig. 15). The legs of these differ but little in length, and the four posterior tibiæ are thick, strongly incised or emarginate, with an extremity greatly widened, and appearing as if stellated in some. This genus contains some large and striking species, such as *O. rhinoceros*, and others, from the East Indies. There are few European species, and of these *O. nasicornis* is by some regarded as indigenous in England. It feeds on tan and rich vegetable mould. Its larva is well known as having furnished the great Swammerdam with the subject of one of his many remarkable anatomical investigations.

Of such as possess maxillæ which are usually corneous or scaly, and more or less dentated, we shall mention the genus SCARABÆUS[2] properly so called (Plate CCXXIV. fig. 17). In these the body is thick and convex, and the external side of their mandibles sinuous or dentated. These insects occur chiefly in the equatorial regions, both of the old world and the new. They are scarcely known in Europe, and do not exist in Britain. *S. punctatus* is found in Italy and the south of France, and *S. monodon* in Hungary. Several species from South America (such as *S. Hercules*) and the East Indies, are remarkable for their gigantic size and extraordinary structure. *S. Atlas*, Fab. (*Hector* of Dejean?), is a native of Java, but it also occurs in the mainland.[3] We know little of the actual history or transformations of these fine insects, but their habits may be inferred to resemble those of *Oryctes*, and other congenerous tribes of the Scarabæides. The larvæ probably dwell in the decaying portions of great timber trees, and no doubt hasten the death and overthrow of these sylvan monarchs. We could dilate with pleasure on the singular aspect of these gigantic Coleoptera, did not the nature of our general plan, and our desire to notice, however briefly, most of the principal genera, preclude our entering into the descriptive details of species. We must therefore rest satisfied with a general reference to the works of Olivier, Fabricius, Latreille, Macleay, and the Catalogue of Dejean, part ii. p. 150.[4] We cannot help, however, here alluding to that principle of association in the human mind, by which size or dimension affects us with such different ideas in relation to different objects. Many may smile at our using the expression "gigantic" or "magnificent" to creatures the largest of which (of the Coleopterous kinds, e. g. *Prionus gigas*) scarcely exceeds six inches in length;—yet true it is, that to an entomologist accustomed only to the European forms of insect life, the first sight of any of the greater Prionidæ, or of *Scarabæus Hercules*, or *Atlas*, or *Actæon*, creates a feeling bordering upon awe, such as that which an enlightened artist may be supposed to experience on first beholding the perfect proportions of some great temple. Our ideas are perhaps equally relative in all departments both of art and nature. An Egyptian pyramid is thought *stupendous*, while North Berwick Law (of about equal height with the greatest of the Coptic monuments) is almost nameless as a Scottish mountain. An eagle, from his size and strength, is called a "feathered king," although his body is less than that of a pig a few months old. A mastiff or Newfoundland dog, being among the largest of the canine kind, is called "majestic," although a sucking elephant might squeeze both of them to death by an accidental stumble,—the said elephant being at the same time regarded as a "poor creature," because it is not a full grown example of the "wisest of beasts." An ancient walrus, floating among the hoary icebergs of the arctic seas, is looked upon as one of the most ponderous of created things; yet a Greenland seaman considers as insignificant, and will scarcely throw his harpoon into the sides of a young whale, which with one blow of its upraised tail could lash the ocean into foam, sink a "captain's gig," and send the walrus with a fractured skull to the bottom of the sea. The same principle is capable of illustration, by the practice of the more enthusiastic disciples of Isaac Walton. Even the most experienced of anglers gazes with delight, almost with wonder, at a river trout of three or four pounds weight. A grilse of the same dimensions, when made to "spurn the indignant shore," is viewed by the salmon fisher almost with a feeling of disappointment. We remember our friend Sir William Jardine killing, *inter alia*, one morning in the Tweed, a salmon of six and thirty pounds weight, in an hour and five minutes, and yet the same skilful angler was greatly astonished by a Loch Awe trout, which, though a giant of its kind, was, when brought to the balance, found wanting by several ounces, in the weight of twelve pounds. But to return to our beetles.

The genus PHILEURUS of Lat. (*Geotrupes* of Fabricius) differ from the Scarabæi in their mandibles, which are straighter, without sinus or dentation on the outer side;

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[1] *'Ορυκτὴς, one who digs.*

[2] The term *Scarabæus* appears to have been either applied by the Romans to coleopterous insects in general, or at least to have been used with a wide and indefinite generic application. The origin of the word is by no means clear, and its derivation from *σκάπτω*, as given by Fabricius and Olivier, has been regarded as inconsistent with the rules of etymology. Mr Macleay thinks it difficult to obtain the word at all from the Greek, and regards it rather as being of Etruscan origin, the more especially as it never occurs in other than ancient *Latin* authors. Let us here note that the *Scarabæi* (properly so called) of Latreille belong to the genus *Dynastes* of Macleay, which includes the "giants of the insect race." We believe, however, that some *Prionidæ* exceed them in size.

[3] The specimen in our collection was *taken at Rangoon* by Sir Archibald Campbell, and obligingly transmitted to us by George Swinton, Esq. We have since received Javanese specimens from Lieutenant Loudon, R. N. of Musselburgh.

[4] Few points are more puzzling, or productive of greater delay in the progress of the student, than the cloud of synonyms by which natural history is overshadowed. This arises partly from ignorance, and partly from the (nearly allied) source of self-conceit, which induce together "confusion worse confounded," in the very face of an expressed desire to enlighten and amend. Even the great masters of the art have sometimes erred in the imposition of their generic names. The reader will bear in mind that *Geotrupes* of Fab. forms no part of the *Geotrupides* of the present day, but corresponds to the genus *Scarabæus* of Latreille; while the genus which bears the latter name in the *Horæ Entomologicæ* is identical in its prevailing parts to the genus *Atcuchus* of the *Systema Eleutheratorum*. There is no doubt that Mr Macleay's genus contains the insects to which the name of Scarabæus was applied by Pliny.

their body is also depressed, and the thorax dilated or rounded laterally. Such are *S. dydimus, vulgus, depressus*, of Fab.

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A second subdivision of the Xylophili contains those genera in which the head and thorax are of similar structure in both sexes, and not characterized by peculiar projections. The anterior margin of the labrum is almost always exposed or apparent. The maxillæ are entirely squamous, as if truncated at the termination, and furnished with five or six strong teeth on their inner edge. The mentum is proportionally shorter and broader than that of the Scarabæi, and less narrowed superiorly. The mesosternum is frequently prolonged to a horn or blunt point between or beyond the second pair of legs. The scutellum is usually large. The hooks of the tarsi are generally unequal. A small number excepted, these xylophilous Coleoptera are peculiar to the equatorial regions of the new world. They resemble in many respects our preceding subjects, and are at the same time nearly allied to the Melolonthæ, and particularly the Cetoniæ, of which they bear the external aspect, although their masticating organs differ. Fabricius and Olivier, in fact, arranged most of these insects with each other. The body of the kinds now under consideration is shorter, more rounded, and smoother than that of the preceding. They moreover differ in being frequently ornamented with brilliant colours.

In some (agreeing in this character with all the preceding Scarabæides), we do not perceive, between the posterior angles of the thorax and the exterior ones of the base of the elytra, an axillary piece filling up as it were the space comprised between these parts.

We shall first notice a genus in which the central portion of the chest presents no pointed prolongation. Such is HEXODON[1] (Plate CCXXIV. figs. 16, 20, 22, and 23), of which the body is almost orbicular, plane beneath; the head square, and received into a deep emargination of the thorax; the exterior margin of the elytra dilated and anteriorly marked by a small groove or gutter; the legs slender, and the hooks of the tarsi small and equal. But in the following genera the sternum is prolonged between the second pair of legs to a conical point. In CHRYSOPHORA of Dejean (*Melolontha chrysochlora*,[2] Lat.), Plate CCXXIV. figs. 18 and 19, the hind legs of the male are very large, the thighs thick, the tibiæ arcuated, and terminated at the inner angle by a very strong point. Here is also placed the *Scarabæus macropus* of Shaw.[3] In RUTELA, Lat. (Plate CCXXIV. fig. 25), there is no remarkable difference in the size of the legs in the two sexes; the mentum is almost isometrical; the scutellum small or moderate; and the sternal point is short,—not reaching to the origin of the two anterior feet. The body is ovoid or oval. MACRASPIS, Macleay (Plate CCXXIV. fig. 26), differs from the preceding in the proportions of the mentum, which is obviously longer than broad; in the short and rounded form of the body; in the length of the scutellum, which at least equals a third of that of the elytra; and in the length of the sternal point, the extremity of which attains to the origin of the two anterior legs, or extends beyond it. The mandibles are almost triangular, with the extremity pointed or emarginate. The maxillæ are furnished with several teeth. One of the hooks of the tarsi, at least of the four anterior ones, is bifid, the other entire. Here Latreille places also the genus CHASMODIA of Macleay.

In other genera we perceive the axillary piece, before alluded to (agreeing with that seen in the same quarter in the Cetonia, and named *epimera* by M. Audouin[4]), filling up the space comprised between the posterior angles of the thorax and the exterior angles of the base of the elytra. Such is the genus OMETIS of Latreille.

SECTION 4TH, PHYLLOPHAGI.[5]

This section, as well as the ensuing, is formed from the great genus *Melolontha* of Fabricius, of which certain species are scattered also among the preceding groups. The Phyllophagi are nearly related to the concluding genera of the third section. Their mandibles, however, are covered above by the epistoma, and concealed beneath by the maxillæ,—their exterior side being alone exposed, but without either protruding or presenting the sinuosities or dentations observed in the Rutelæ and other analogous genera. The anterior edge of the labrum is exposed, and is sometimes of the form of a broad reversed triangle, sometimes (and more frequently) of a transverse lamina, emarginate in the centre. The number of the articulations of the antennæ is by no means uniform, and varies from eight to ten. The same observation applies to those of the club, which in several differs even in the sexes of the same species. The ligula is entirely covered by the mentum, or incorporated with its anterior face, and the elytra meet completely along the whole of the dorsal suture,—characters which distinguish our present species from those of the fifth or ensuing section.

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The family of ANAPLOGNATHIDES of Mr Macleay, and some other genera nearly allied to the preceding, form the first subdivision according to M. Latreille's views. The epistoma is thickened anteriorly, and forms, either alone or with the labrum, a vertical facette in the form of a reversed triangle, the point of which rests on the mentum. This last-named portion is sometimes almost ovoid, densely pilose, with the extremity either rounded or truncated, and without emargination,—sometimes in the form of a transverse square, with the middle of the superior margin prolonged into a tooth, simple or emarginate. The maxillæ of some terminate by a coriaceous or membranous lobe, very hairy, without teeth, or with a very small number, and situate near the middle of the internal border;—those of the others are entirely corneous, resemble mandibles, and are either truncated or obtuse and entire at the end, or terminated by two or three teeth.

In the genera PACHYPUS of Dejean, and AMBLYTERES of Macleay, the mentum is almost ovoid; and in the former the antennæ of the males are composed of only eight joints, of which the last five form the club,—in the latter they consist of ten joints, of which the last three form the club.

In the other genera of this subdivision the mentum forms a transverse square, the centre of the superior margin projecting in the manner of a tooth, entire or emarginate. In the genus ANAPLOGNATHUS of Leach (peculiar to Australasia) there is a sternal projection, and the hooks of the tarsi are entire and unequal. The antennæ are composed of ten joints, and the extremity of the maxillæ is truncated, or obtuse and entire. These insects are

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[1] From ἑξ, *six*, ὀδους, *tooth*, in allusion to the amount of dentations of the maxillæ. See Plate CCXXIV. fig. 16.

[2] *Voyage de MM. Humboldt et Bonpland*, ii. xv. 1, fem.; 2, male.

[3] *Naturalist's Miscellany*, 380, iv.

[4] *Memoire sur le Thorax des Insectes.*

[5] From φυλλον, *a leaf*, and φαγος, *eating*.

Coleoptera Pentamera.

of considerable size, and of rather brilliant aspect.[1] Here also are placed the genera Leucothyreus of Macleay, and Apogonia and Geniates of Kirby.

* *

A second subdivision of the *Phyllophagi*[2] of Latreille contains the Melolonthidæ of Macleay. In these the labrum is in the form of a transverse plate or leaflet, generally strongly emarginate beneath in its centre, so that when seen in front it exhibits the figure of a reversed or demi-truncated heart. The mentum is as long if not longer than broad, somewhat narrowed anterior to the summit, and either nearly square or heart-shaped; its superior margin is straight, or more or less emarginate or concave, in the middle, but without any tooth-like dilatation. The maxillæ are usually squamous, and armed with several (frequently five or six) teeth. This subdivision is itself capable of a further partition into two groups, the first corresponding to the genus *Melolontha* of Fabricius, as restricted by Illiger and Latreille—the other to the genus *Hoplia* of Illiger. The former continues to bear the name of

MELOLONTHIDES.

Distinguishable by the following general characteristics. The number of complete leaflets of the club exceeds three in several genera. The form of the body is usually thick and massive. The mandibles are strong, entirely or in greater part corneous, and exhibiting at most only a membranous and hirsute appendage, placed in the emargination of the inner side; the superior extremity is strongly truncated, with two or three teeth or angular projections. All the tarsi are terminated by two hooks; the first article of the two anterior being prolonged inferiorly into a hooked appendage. The labrum is usually apparent,—the maxillary teeth robust.

The insects of which this group is composed were included by Linnæus, like all those with which we have been lately engaged, in his extensive genus *Scarabæus*, and they also continued to form a portion of that genus in the works of Geoffroy, Degeer, Schæffer, and other entomologists prior to the time of Fabricius. The last-named author established the genus *Melolontha*, which in its extended signification may be regarded as synonymous with the Melolonthides of Latreille. Were we to follow the prevailing and praiseworthy example of botanists, who bestow upon a *family* the name of the *genus* by which it is most strongly characterized, our present group ought to be denominated *Sericides*, in as far as the type is not formed by *Melolontha vulgaris*, but rather by *M. brunnea* of Fabricius, which now constitutes the genus *Serica* of Macleay. But as it is at all times desirable that families should be named after well-known genera, the designation now adopted is preferable to that which might be derived from the less noted though more characteristic type. The Melolonthides are not often distinguished by brilliant or metallic colouring. Their elytra, of which brown is a characteristic colour, are generally slightly scaly or hirsute. Throughout the entire period of their existence these insects live on vegetable substances, and their ravages are often extremely injurious. The larvæ are very long lived, and sometimes pass three or four years in that destructive state. In cold and temperate climates they are very sluggish, if not torpid, during winter, and descend somewhat deeper into the earth to avoid the effects of frost. The perfect insects feed on leaves,—the larvæ for the most part on roots.

In the genus Melolontha properly so called (from *μηλεα, an apple-tree*, and *ἄνθησις, inflorescence*[3]), see Plate CCXXIV. fig. 29, the antennæ are ten jointed, with the five or seven terminal joints in the males, and the six or four in the females, composing the club. The labrum is thick and strongly emarginate beneath. All the hooks of the tarsi are equal, and terminate in a point entire or simply uni-dentate at their base. The posterior extremity of the abdomen usually ends in a point or style, at least in the males. Of the species of which the antennal club in the male consists of seven leaflets, in the female of only six, we shall here notice the common cockchafer, *M. vulgaris* (*S. Melolontha*, Linn.). The body of this insect is of a pitchy black, with a whitish pubescence; the sides of the abdomen are marked by a range of triangular spots. The elytra are testaceous. The antennæ of the males are much larger than those of the females. (Plate CCXXIV. figs. 21 and 24.) This, though a most abundant insect in England, and over most parts of Europe, is less generally known in Scotland, and is rare in the Edinburgh district. Specimens, however, have been procured in the park of Dalkeith House, in Lanarkshire, at Lorn in Ayrshire,[4] at Raehills and Moffat in Dumfriesshire, and as far north as Glencoe.[5]

We may observe that the existence in the perfect state of the species above named is of very short duration. The life of an individual is supposed not to extend beyond a week, and the entire species during each successive season prevails only for the space of a single month. The male speedily perishes after the sexual union, and the female merely survives for a sufficient time to deposit her eggs in safety. As soon as the latter is fecundated, she digs a hole in the earth of about half a foot in depth, by means of her dentated fore legs. The larvæ which proceed from these eggs are soft, lengthened, of a dingy-white or yellowish colour; they have six short scaly feet, a large scaly head, two antennæ, each composed of five pieces, and nine stigmata on each side of the body. The eyes are not at first visible—being concealed under the skin, which is ere long cast off. These destructive creatures feed upon the roots of various plants. They are most voracious during the summer season. In the course of the autumn they descend into the earth, and pass the winter in a state of profound repose, neither requiring nor desiring food. As soon as the solar rays produce their genial influence in early spring, they ascend within six inches of the surface, and recommence their ravages. They change their skin every year, assume the nympha state in the course of the third autumn after they are hatched, and appear in the perfect state during the ensuing spring or early portion of summer. The beetle, when it first escapes from its cocoon, is pale and soft, and does not venture to leave its subterranean chamber for some time. But ere long it acquires a firm consistence, and crawling to the surface, it expands its wings, and mounting into the air, is henceforward no more a subterranean dweller, but seeks its nourishment among the umbrageous branches of the loftiest trees.[1]

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[1] See *Hor. Ent.* p. 143; and *Linn. Trans.* vol. xii. pp. 401–5; also Leach's *Zoological Miscellany*, vol. ii. p. 44.

[2] Misnamed (we presume accidentally) *Xylophiles* in the second edition of the *Règne Animal*, t. iv. p. 558.

[3] Μηλολονθη, or Μηλανθη, is a term of frequent occurrence in Aristotle and other ancient authors, and was first applied by Fabricius to the insects of the present genus. It is derived from the words mentioned above, because the insects it denoted either were supposed to be produced from the flowers of fruit-trees, or were accustomed to resort to them for food. This circumstance renders it probable that the *μηλολονθη* of the ancients belonged to the family Cetoniides, as the true Melolonthides are hardly ever seen on flowers; and the description of Eustathius, who says that the animal resembled a wasp, led Mr Macleay to conjecture that it might be the *Trichius fasciatus*, a vernal beetle common in Greece, which might be readily mistaken by a casual observer for one of the Hymenoptera, as it bears a considerable resemblance to some of the members of that order, both in its colouring and mode of flight. Mouffet's investigations led him to a very different conclusion—that the insect was of a metallic green, and referable to the *Buprestides*. The former opinion is greatly the more probable, and accords with the brief notices on the subject found in ancient writers, particularly Hesychius and the scholiast on Aristophanes; but these notices are too imperfect to warrant the determinate application of a word obviously used with considerable latitude of meaning, and intended in all probability to indicate a group or tribe of insects rather than any individual species. (See *Hor. Ent.* p. 78; and Mouffeti, *Theat. Insect.* xxi. 158.)

[4] Professor Rennie, in *Insect Transformations*, 225.

[5] *Ent. Ed.* p. 188.

Although the generality of insects are more destructive in the larva than in any other state, great ravages are occasionally committed even by the perfect insect. It is in relation to the present species that Mouffet records the number of beetles which at one time fell into the Severn as being sufficient to stop the wheels of the water-mills. In the year 1688 they covered the hedges and trees in a district of the county of Galway, in such infinite numbers as to hang in clusters like bees when they swarm. When on the wing they almost darkened the light of day, and produced a peculiar sound by the rustling of their wings. When feeding, the noise of their jaws might have been mistaken for the sawing of timber; and in a very short time the foilage of the trees for miles around was so totally consumed, that at midsummer the country wore the aspect of the leafless winter.[2] "One of the worst of these ravagers," say Messrs Kirby and Spence, "is the grub of the common cockchafer. This insect, which is found to remain in the larva state for four years, sometimes destroys whole acres of grass, as I can aver from my own observation. It undermines the richest meadows, and so loosens the turf that it will roll up as if cut with a turfing spade. These grubs did so much injury about seventy years ago to a poor farmer near Norwich, that the court of that city, out of compassion, allowed him L.25, and the man and his servant declared that he had gathered eighty bushels of the beetle.[3] In the year 1785 many provinces of France were so ravaged by them that a premium was offered by the government for the best mode of destroying them. They do not confine themselves to grass, but eat also the roots of corn; and it is to feast upon this grub more particularly that the rooks follow the plow.[4]"

The scarcity of this species in Scotland saves it from the fate often inflicted in the south, where *spinning a cockchafer* is a favourite amusement among school-boys. When the larger Coleoptera fall upon their backs, they have some difficulty in resuming their natural position,—and in Sweden, according to Sparmann, there is a fond belief among the simpler of the common people, that their sins will be forgiven them if they set a cockchafer upon its legs. If this creed be true, our English youths have much to answer for.[5]

The only other species of the genus which we shall mention is *M. fullo* (Plate CCXXIV. fig. 29), one of the largest of the European Coleoptera. It is sometimes nearly an inch and three quarters long, of a brown or blackish colour, marked with many irregular white spots. The club of the antennæ in the males is remarkably large. This species occurs chiefly on downs along the maritime shores of Europe. It is sometimes captured in England. We have received it from Persia and other eastern countries.

In the genus RHISOSTROGUS of Lat. (formerly AMPHIMALLA of the same author), the species closely resemble the preceding; but the antennæ, consisting of nine or ten joints, have only three leaflets in the club. Such is a well known English insect not yet ascertained to inhabit Scotland, *R. Solstitialis*. In the genus AREODA of Leach and Macleay (Plate CCXXIV. fig. 30) the antennæ have ten articulations, the sternum is corneous, and all the hooks of the tarsi are equal in those individuals presumed to be females, and unequal in such as are regarded as males. The species are brilliantly adorned, and inhabit Brazil. All the preceding phyllophagous genera, it may be observed, with few exceptions, are furnished with ten articulations to the antennæ; but in the following Melolonthides there are only nine. In PHYLLOPERTHA of Kirby (from φυλλον, a *leaf*, and περθω, *to destroy*), the antennæ are only nine jointed. Here we place a species which often appears in prodigious quantities among ferns on commons in many parts of Britain. It is called the Bracken-clock in the north of England—*P. horticola*. It falls into the genus *Anisoplia* of Megerle and Dejean. A larger and much rarer species is *P. Frischii*. It has been found near Montrose. In the genus SERICA[6] of Macleay (Plate CCXXIV. figs. 27 and 28), the joints of the antennæ seem to have been differently computed.[7] All the hooks of the tarsi are bifid. The body is ovoid, arched, with a silky aspect, and changeable reflections. Certain insects, as yet found only in New Holland, form the genus DIPHUCEPHALA[8] of Dejean. Their tarsi are bifid, as in the preceding, but the body is narrow and elongated, and the thorax square. In EUCHLORA of Macleay (Plate CCXXV. fig. 1 and 2), the hooks of the tarsi are unequal, and there is no sternal projection; one of the hooks of the four anterior tarsi is bifid in the males, the body is arched, the epistoma short and transverse.

The second group of this subdivision, or the third and last of the Phyllophagi, is called

HOPLIDES,

and is characterized as follows. The mandibles are small and depressed, and as if divided longitudinally into two parts, of which the internal is membranous, the external corneous; the superior extremity presents no sensible dentations. The labrum is concealed or but slightly apparent. The maxillæ have frequently only small dentations. The body is short, depressed, broad, with the elytra narrowed posteriorly at the exterior side. The last two tarsi are usually furnished with but a single hook. In such as have two hooks to all the tarsi (genus *Dicrania*), the first joint of the anterior tarsi is prolonged inferiorly, and exhibits on the internal side a strong hooked tooth.

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[1] Some very laborious and beautifully elaborated works have been recently published on the anatomical structure of the Melolonthæ. See more particularly *Considérations générales sur l'Anatomie comparée des Animaux articulés, auxquelles on a joint l'anatomie descriptive du Hanneton*, par M. Straus, 1 vol. in 4to, with plates. Paris, 1828. The illustrious and lamented Cuvier has observed of this production, that it is the only work fit to be compared to that of Lyonnet, *Sur la Chenille du Saule*. M. Dufour has also explained the digestive system of these insects, in the 3d vol. of the *Ann. des Sciences Nat.*; while the muscular economy of the wings and thorax has been described and figured by the accurate Chabrier, in his *Essai sur le Vol des Insectes*. Paris, 1823.

[2] *Phil. Trans.* xix.

[3] *Phil. Trans.* 1741, 581.

[4] *Introd. to Ent.* vol. i. p. 177.

[5] We may here record that the *Melolontha hippocastani*, Fab. (Olivier, i. 3, a, b, c) was taken by the writer of this article some years ago on the banks of Windermere. It was formerly confounded with *M. vulgaris*, but is distinguished by being rather smaller, shorter, and more convex; the elytra are narrowly margined with black, and the terminal style of the abdomen is rather shorter, and has a slight constriction or neck, which makes the extremity appear broader and more obtuse. It does not seem to be known as British to the English collectors. (See *Entomologia Edinensis*, p. 190, note.)

[6] From σηρικον, *silk*.

[7] Antennæ articulis decem, *Hor. Ent.* 146. Je n'en compte que neuf, *Règne Animal*, iv. 562.

[8] From διφυης, *double*, and κεφαλη, *head*.

M. Leon Dufour, as Latreille informs us, has remarked, that the digestive canal in these insects (at least in such *Hopliæ* as he has examined) is much shorter than that of the Melolonthæ, and rather approaches the same part in the genus Cetonia. The chylific ventricle is smooth and flexuous. The small intestine is shorter than in Melolontha, and often presents an ovoid inflation at its origin. The great intestine is elongated, and destitute of valvular anfractuosities, and the rectum is distinctly marked by an obvious collar. The generative system resembles that of the Melolonthæ.

In the genus Dicrania (Lepel. and Serville, in *Encyclop. Meth.*), besides the characters alluded to above, the body is very smooth, without scales, the scutellum rather large, and there are two strong spines at the extremity of the four posterior tibiæ; the lower extremity of the two hindmost tibiæ is dilated. These insects are natives of Brazil. In the genus Hoplia of Illiger there is only a single hook to the two posterior tarsi (Plate CCXXV. fig. 4). The pairs of the others are bifid and unequal. The extremity of the intermediate and hind tibiæ is as it were crowned by little spines of nearly equal length. The body is generally furnished with minute scales. The epistoma is either almost square or nearly semicircular. The thighs of the two hind legs are moderately enlarged, and the tibiæ are long, straight, and without a hooked tooth at their extremity. *H. farinosa* (Plate CCXXV. fig. 3), one of the most beautiful of European Coleoptera, is a common insect in the south of France. The antennæ are nine-jointed, the body is covered with silvery scales, of a pale but bright and ethereal blue, with a greenish or golden tint beneath. This species, on which a British entomologist gazes with great delight, is common in several European countries, near the banks of brooks and rivers.

Section 5th, Anthobii.[1]

The scarabideous insects of this section also formed a portion of the undivided genus Melolontha, and are nearly allied to the concluding members of the preceding groups. Their paraglossæ, however, or divisions of the ligula, project beyond the upper extremity of the mentum, and the edges of the elytra are somewhat open, or removed from the usual line of the dorsal suture, towards their posterior extremity, which is narrowed to a point, or rounded. The antennæ consist of from nine to ten joints, of which the three last alone form the club in both sexes. The terminal lobe of the maxillæ is often almost membranous, silky, in the form of a pencil,—in others it is coriaceous and dentated along the inner edge. The labrum and mandibles are more or less solid, according as these parts are exposed or covered. These insects live among flowers and the varied foliage of shrubs and trees.

In the genus Amphicoma,[2] Lat. (Plate CCXXV. figs. 5 and 6) the first joint of the antennal club is concave, and encases the others. The mandibles are rounded and curved on the exterior side, without dentation on the inner margin; the antennal mass is globular, the abdomen soft, and all the legs of ordinary size. The epistoma is distinctly margined. The anterior tibiæ have three teeth on their outer edge. The first four articles of the tarsi are strongly ciliated in the males. These singular insects can scarcely be regarded as European, although they do occur occasionally in Greece. They are more frequent in the south of Russia, and in the western parts of the Persian dominions. Comte Dejean informs us that *A. hirta*, Fab. is the female of *A. vulpes* of the same author. *A. vulpecula*, with which we were favoured by M. Faldermann of the Imperial Botanic Gardens of St Petersburg, appears to be also a variety of the first-named insect. The only other genus of this section which we can here notice is Anisonyx of Lat., an example of which is given in Plate CCXXV. figs. 7 and 13.

Section 6th, Melitophili.[3]

In these the body is depressed, usually oval, brilliant, hornless, with the thorax trapeziform or almost orbicular. An axillary piece occupies, in the greater number, the space comprised between the posterior angles and the exterior of the base of the elytra. The anal termination is exposed. The sternum is frequently prolonged in the form of a point or advanced horn. The hooks of the tarsi are equal and simple. The antennæ are 10-articulate, with the last three joints forming the club, which is always foliaceous. The labrum and mandibles are concealed, lamelliform, and nearly if not entirely membranous. The maxillæ terminate in a silky lobe, in the form of a pencil, without corneous teeth. The mentum is usually ovoid, truncated superiorly, or almost square, with the middle of the superior edge more or less concave or emarginate. The ligula is not projecting.

The alimentary tube of these insects, according to M. Dufour, is shorter than in any of the scarabideous family. The chylific ventricle has usually its external tunic covered by very small superficial papillæ, or projecting points. The enlargement which terminates the small intestine is not cavernous, as in the Melolonthæ.[4] The larvæ are said to live in decayed wood. In the perfect state they occur on flowers, and not unfrequently also on the trunks of such trees as exude any fluid.

This section, according to the views of M. Latreille, by which we have already been so long guided, is susceptible of division into three principal groups, corresponding to the genera *Trichius* of Fabricius, *Goliathus* of Lamarck, and *Cetonia* of Fabricius, but reduced and simplified by certain abstractions.

The Melitophili of the first two divisions have no strongly-marked sternal projection; the lateral portion of the mesosternum (or that named *epimera* by M. Audouin) does not generally manifest itself upwardly. The thorax does not increase from before backwards as in Cetonia; nor is the exterior side of the elytra abruptly narrowed or uni-sinuate a little below the humeral angle, as in those insects. A more rigorous character consists in the labial palpi being inserted in lateral grooves of the anterior face of the mentum, so that they are entirely exposed, the sides of the mentum jutting beyond them at their origin, and protecting them behind. In the first two divisions these palpi are inserted beneath the lateral margin of the mentum, or in the margins themselves, in such manner that the first articulations, when viewed from before, do not appear.

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[1] From ανθος, *a flower*, and βιος, *life*.

[2] From αμφι, *about*, or *on both sides*, and κομη, *hair*, in allusion to the frequent covering with which the species are invested.

[3] From μελι, *honey*, or μελιτοω, *to make honey*, and φιλος, *a lover*.

[4] For other details, especially for such as illustrate the generative system, see *Annales des Sciences Nat*. t. iii. p. 235, and t iv. p 178.

1*st*, TRICHIDES.

In these the mentum is either almost isometrical, or rather longer than broad, and leaves the maxillæ exposed. They correspond, as we have said, to the genus TRICHIUS of Fabricius (Plate CCXXV. figs. 8 and 9), of which we may mention as an example *T. fasciatus*, probably the only British species. It is black, with scattered yellow hairs, the elytra yellowish, with three transverse black bands, interrupted at the suture. It is very rare in Scotland, but is, however, recorded by Mr Curtis as occurring "on the flowers of the thyme, near Loch Rannoch, in July." It was also noticed some years ago by Dr Greville in Glen Tilt, and we saw it taken by Mr Giles Munby, on the southern border of Sutherland, early in the month of August 1833. The dimensions of the female considerably exceed those of the male. The genus, as now restricted, is not very extensive. Dejean enumerates twelve species, several of which are from North America.

2*d*, GOLIATHIDES,

May be distinguished from the preceding by the mentum, which is much longer and wider, and covers the maxillæ. In some the mentum is concave in the centre. The anterior extremity of the epistoma is neither toothed nor horned. Such is the genus CREMASTOCHEILUS of Knock (Plate CCXXV. fig. 10), in which the thorax forms nearly a transverse square; the maxillæ are terminated by a strong tooth, hooked or falciform, with setæ or little spines in place of an inner lobe; the last article of the palpi is very long and cylindrical; the mentum in the form of a widened heart, or of a reversed triangle rounded at the upper angles, without sensible emargination. In others the mentum is in the form of a greatly widened heart, but without a discoidal cavity, its superior edge being emarginate or sinuous. The anterior extremity of the epistoma in the males is divided into two lobes, in the form of obtuse or truncated horns. The thorax is almost orbicular. Such is the extraordinary genus GOLIATHUS of Lamarck (*Cetonia* of Fab. and Olivier), Plate CCXXV. figs. 14 and 16, which contains some of the largest and most striking of coleopterous insects. One of the species which we have represented appears to exhibit some variation in its markings.[1] The same species seems figured by Drury (*Illustrations*, vol. i. pl. 31), who says it was brought from Africa, where it was found "floating dead in the river Gaboon, opposite Prince's Island, near the equinoctial line." The only specimen with which we are now acquainted is that preserved in the Hunterian Museum, Glasgow. Mr Kirby has described two smaller species from Brazil.[2] Other kinds form the genus INCA of modern writers.[3]

3*d*, CETONIIDES.

In this group the sternum is more or less prolonged to an obtuse point, between the intermediate pair of legs; the axillary piece before mentioned is always visible above, and occupies the entire space which separates the posterior angles of the thorax from the base of the elytra; the thorax is usually enlarged posteriorly, and has the form of a triangle truncated anteriorly or at its point. The mentum is never transversal; its superior margin is more or less emarginate in the middle. The terminal lobe of the maxillæ is silky or pencil-shaped. The body is almost ovoid, and depressed. The membranaceous texture of the mandibles and maxillæ of these insects demonstrates, as Mr Macleay has observed, that in the perfect state they live on vegetable juices. Thus *C. morio*, Fab. and doubtless many others, especially of the darker coloured kinds, regale themselves on the sap of wounded trees,—while *C. aurata* and its brilliant allies are only found on flowers.[4] The Cetoniides, though in general gay and ornamental insects, yield in metallic splendour to several species of the genera *Rutela*, *Glaphyris*, and *Anaplognathus*. "Nothing, however, can exceed the beauty and lustre of the polish, or the admirable variety of ornament, with which their elytra are adorned. The larvæ live in the fattest vegetable soils; but notwithstanding the excellent observations of Degeer, much remains to be performed towards the elucidation of this part of their history."[5]

Sufficient data have not yet been collected for the proper elucidation of their geographical distribution, but it appears that many more species exist within than without the tropics. In some the thorax is prolonged posteriorly in an angular form, so that the scutellum disappears. These form the genus GYMNETIS of Macleay (Plate CCXXV. fig. 12). Several species occur in America. In others from New Holland and the East Indies the clypeus is bifid, or armed, in the males, with a couple of horns, and the body is proportionally narrow and elongated, with the abdomen obviously decreasing in size posteriorly. It is even almost triangular in some. The club of the antennæ is elongated. These constitute the genus MACRONOTA of Wiedemann (Plate CCXXV. fig. 15). "Mais toutes ces coupes n'acquerront de la solidité que lorsqu'on aura fait un étude particulière des nombreuses espèces du genre Cetonia de Fabricius."[6]

The European Cetoniæ are provided with a scutellum of ordinary size. *C. aurata* (commonly called the rose-beetle) is well known in many parts of England. It is nearly an inch long, of a brilliant golden green above, with coppery red reflections beneath, and some whitish markings on the elytra. It has been taken in Morayshire by the Misses Dick Lauder, and is also known to have occurred in Dumfriesshire. It is still, however, to be regarded as *inter rariores* of the Scottish species. Dejean's Catalogue contains 125 Cetoniæ, of which the greater part are foreign to Europe. They occur over all the warmer regions of the earth. Java produces several of great beauty, of which *C. Macleayi* is described, and figured by Mr Kirby in his *Century of Insects*.[7] The one which we have represented, *C. Baxii* (Plate CCXXV. fig. 11), is highly prized by collectors.

TRIBE 2D, LUCANIDES.

In this second tribe or principal division of the lamellicorn Coleoptera, which derives its name from the genus Lucanus of Linnæus, the club of the antennæ is composed of leaflets or dentations disposed perpendicularly to its axis, like the teeth of a comb. These organs always consist of ten joints, of which the first is usually much longer than the others. The mandibles are always corneous, generally projecting, and of larger size as well as of different form in the males. The maxillæ in most terminate in a narrow lobe, lengthened and silky; in others they are entirely corneous and dentated. The ligula in the greater number is formed of two small silky pencils, more or less projecting beyond the mentum, which is almost semicircular or square. The anterior legs are generally elongated, with the tibiæ dentated all along their outer edge. The tarsi are terminated by two hooks, equal, simple, with a small appendage, ending in two setæ, between them.[1] These insects compose two sections which correspond to the genera *Lucanus* and *Passalus* of Olivier.

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[1] See Olivier, *Coléoptères*, No. 6, pl. 5, fig. 33, et pl. 9, fig. 33. We are indebted to Mr Joseph Dalton Hooker for an accurate drawing of the valuable specimen in the Glasgow Museum. We did not receive it till the figure above referred to had been copied by our engraver from Olivier's work.

[2] *Linn. Trans.* vol. xii. p. 407.

[3] *Encyclopédie Méthodique*, art. *Scarabeides*. See also Dejean's *Catalogue*, p. 168.

[4] *Hor. Ent.* p. 74.

[5] *Ibid.* p. 75.

[6] *Règne Animal*, t. iv. p. 574. We observe a work *On the Family of the Cetoniides*, recently announced in France as preparing for publication, and from which, we doubt not, the entomologist will derive advantage.

[7] *Linn. Trans.* vol. xii.

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In the first the antennæ are greatly bent or geniculate, smooth, or but slightly hirsute; the labrum small, or confounded with the epistoma; the maxillæ terminated by a membranous or coriaceous lobe, very silky, pencil-shaped, without teeth, or with one at most; the ligula either entirely concealed, or incorporated with the mentum, or divided into two narrow elongated silky lobes, more or less projecting beyond the mentum. The scutellum is placed between the elytra.

In some genera the antennal club consists only of from three to four joints or leaflets. Such are Synodendron[2] of Fab. (Plate CCXXV. fig. 20), Æsalus of Fab., Lamprima of Lat. (ibid. figs. 17 and 22), Ryssonotus, Macleay (*Luc. nebulosus* of Kirby), Philodotus, Macl. (ibid. fig. 19), and Lucanus properly so called (ibid. fig. 18). To the last belongs *L. cervus* (Plate CCXX. figs. 1, 2, 3), the largest and most formidable looking of the British Coleoptera. It inhabits the interior of oaks and beeches for several years before assuming its final transformation, and is by some regarded as the *Cossus* of the ancients, a vermiform larva, long regarded as a delicious food, but not now coveted by the refined epicures of modern days.[3] In other genera of this section the club of the antennæ, as in Syndesus of Macleay, is composed of the seven terminal articulations.[4]

* *

The Lucanides of the second section have the antennæ simply bent, or but slightly geniculate and hairy; the labrum is always exposed, crustaceous, and transversal; the mandibles strong and much dentated, but without any remarkable disproportion of size between the sexes; the maxillæ are entirely corneous, with two strong teeth at least; the ligula, likewise corneous or very hard, is placed in the superior emargination of the mentum, and terminated by three points. The abdomen is supported on a kind of pedicle, bearing the scutellum above it, and separated from the thorax by a neck or obvious interval. These insects form the genus Passalus of Fabricius (Plate CCXXV. figs. 21 and 23), which has undergone subdivision in recent times. In Paxillus of Macleay, for example (fig. 23), the club of the antennæ is composed of five joints, the labrum is very short, the maxillæ have but two teeth, one terminal, the other on the inner side.[5] Mr Macleay restricts Passalus to such species as have only three articulations to the club of the antennæ, as shown by fig. 21. The last-named author here places the genus *Chiron*, which Latreille classes with the coprophagous tribe. All these insects are foreign to Europe, and we believe also to Africa. They are characteristic chiefly of South America, but are also known in New Holland, Java, and the eastern countries of Asia. Madame Merian informs us that the larva of the species figured in her work feeds on the roots of the sweet potato. The perfect insect is well known in sugar-houses.

HETEROMERA.

Five Articulations to the first four Tarsi, and four to the hindmost pair.

All the groups of this, the second primary section of the coleopterous order, feed on vegetable substances. Latreille comprises them under four great families, of which the first two exhibit, by reason of an excrementitious apparatus discovered by M. Dufour, an analogy to some of the pentamerous Coleoptera. Their chylific ventricle is also frequently beset by papillæ. In several of these insects we find the vestiges of another secreting apparatus, of which we have few examples among the Coleoptera, that denominated the *salivary apparatus*. The hepatic vessels, as in the preceding or pentamerous section, with few exceptions, amount to six in number, and have two intestines, distant from each other; at one extremity, according to Dufour, they are inserted by six insulated ends around the collar which terminates the chylific ventricle; at the other they open into the origin of the cæcum by trunks varying in number in different families and genera.

The first general division of the section may be made to contain the first three families. The elytra are generally of a firm and hard consistence, the hooks of the tarsi almost always simple, the head ovoid or oval, susceptible of being sunk posteriorly in the thorax, or sometimes narrowed behind, but not abruptly, and without any neck at the base. Many of these insects are "darklings," that is, lucifugous or light-shunning.

FAMILY I.—MELASOMA.

This group consists of black or ash-coloured species, without mixture or variety of colour, from which circumstance they derive their name.[6] They are for the most part apterous, with the elytra as it were soldered together. The antennæ are partly or entirely granose, almost of the same size throughout, or a little enlarged at their extremity, inserted under the projecting margin of the head, with the third articulation generally elongated. The mandibles are bifid or emarginate at the extremity, and there is a corneous tooth or hook on the inner side of the maxillæ. All the articulations of the tarsi are entire, and the eyes are oblong and but slightly elevated—a character which, according to M. Marcel de Serres, indicates nocturnal habits. Almost all these insects dwell upon the ground, either in sandy soils or under stones, and they are not unfrequent in cellars, stables, the ground floors of houses, and other dark and sombre situations. According to M. Dufour,[1] the insertion of the biliary vessels takes place on the under surface of the cæcum, by means of a single tubular trunk resulting from the junction of two strong short branches, themselves composed of the reunion of three biliary vessels. The bile is yellow, sometimes brown, or even violet coloured. The alimentary tube[2] is long; in the first tribe, that of the Pimeliariæ, three times the length of the body. The œsophagus is long, and leads to a crop, smooth or glabrous externally, more developed among the last-named insects, where it forms an ovoïd sac lodged in the pectus; it is furnished interiorly with folds or longitudinal fleshy columns, terminating in some species, such as *Erodii* and *Pimeliæ*, beside the chylific ventricle, at a valve formed of four principal corneous, oval, and connivent parts. The chylific ventricle is elongated, flexuous or doubled, generally beset with small papillæ or projecting points, and terminates in a small collar, callous within, which receives the first insertion of the biliary vessels. In the genera *Blaps* and *Asida* there is a salivary apparatus, consisting of two floating vessels or tubes, sometimes, as in the latter, perfectly simple, sometimes, as in the former, irregularly branched. The same structure no doubt will be found to occur in others of the family. The texture of the tunics of the alimentary canal has been studied with great care and assiduity by M. Marcel de Serres.[3] The adipose tissue is more abundant in these Heteromera than in the ensuing; and it is probably this provision which enables them, even when transfixed and fastened down by a pin, to live for six months without food—a fact witnessed (we presume accidentally) by Latreille in a species of *Akis.*

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[1] See our elementary plate (CCXX.) figs. 1, 2, and 3.

[2] From Σὺν, *with*, and Δενδρον, *wood*.

[3] As we have given figures on the plates above referred to, of most of the genera just named, we abstain from entering into the details of their respective characters.

[4] For a description of the singular genus Chiasognathus of Stephens, see the *Cambridge Philosophical Transactions* for 1831.

[5] The insect which we have figured under the name of *Passallus pentaphyllus*, is, we believe, synonymous with *Paxillus Leachii* of Macleay, *Hor. Ent.* p. 106.

[6] From *μέλας*, *black*, and *σῶμα*, *body*.

Our present family, which corresponds to the ancient unrestricted genus *Tenebrio* of the Linnæan system, is subdivided according to the absence or presence of the wings.

TRIBE 1ST, PIMELIARIÆ.[4]

Apterous, the elytra generally fixed or soldered. Palpi almost filiform, or terminated by an article not greatly dilated, and not forming a distinct triangular or securiform mass.

In the genus PIMELIA properly so called,[5] the body is more or less ovoid and oval, with the thorax narrower even at the base than the abdomen, generally convex, without sharp prolongations at the posterior angles, or posterior projection at the præsternum. These insects are proper to the basin of the Mediterranean, to the western and southern parts of Asia, and to Africa.

In the three following genera the body is ovoid, short, arched or gibbous above, with the thorax short, as broad posteriorly as the base of the elytra, and terminated on each side by a sharp angle. The præsternum is dilated posteriorly in the manner of a lamina or point, with its posterior extremity resting on the mesosternum. In ERODIUS, Lat. the last two joints of the antennæ are united, and form a little button-shaped mass. The anterior tibiæ have a strong tooth near the middle of the exterior side, and another on the same side at the end. The mentum is incased (*encadré*) inferiorly, and covers the base of the maxillæ. *E. gibbus*, which is black, the elytra with thin raised lines, occurs in Portugal. In ZOPHOSIS,[6] Lat. the antennæ are almost filiform, or enlarge insensibly towards the end. The anterior tibiæ want the teeth. *Z. testudinarius* is black, the elytra chagrined, and covered on the sides with a whitish powder. It occurs at the Cape. In NYCTELIA, Lat. (Plate CCXXV. fig. 24), the third article of the antennæ is much larger than the preceding, and the following, as well as the ninth and tenth, are almost globular. The base of the maxillæ is exposed. The species are proper to South America.

In the genus HEGETER, Lat. the thorax assumes the form of a trapezium, almost as broad at the posterior margin as the base of the elytra, against which it is applied throughout its breadth. The terminal article of the antennæ is rather less than the preceding. In TENTYRIA of Lat. (*Akis*, Fab.) the thorax is almost orbicular, sometimes narrower than the abdomen, sometimes of the same breadth, but rounded at the posterior angles, and leaving an hiatus between them and the base of the elytra. The terminal article of the antennæ is as large as the preceding. These, as well as the following genera, are peculiar to the warm and western countries of the ancient continent.

The genus AKIS[7] of Fab. (Plate CCXXV. fig. 25) is now restricted to those species in which the thorax is wider than the head, strongly emarginate before, short, its posterior margin widely truncate, and the lateral edges turned up. The antennæ consist of eleven distinct articulations. In EURYCHORA,[8] Thunberg, the body is oval, with acute and ciliated edges, the thorax semicircular, and receiving the head in an anterior notch, the abdomen almost heart-shaped, and the antennæ composed of linear articulations, compressed or angular, of which the third is the longest, and the eleventh indistinct.

The following genera of this tribe differ from the preceding in the mentum, of a square form, not being either emarginate or widened at its upper margin. In TAGENIA of Lat. (*Akis*, Fab.) the thorax is narrow, and either cylindrical, or in the form of an elongated heart, truncate at both ends. The antennæ are almost perfoliate, with the third articulation scarcely longer than the following ones, and the eleventh or last extremely small, and closely united with the preceding. The head is elongated posteriorly, and borne upon a kind of neck or knob. In SCAURUS,[9] Fab. the thorax is at least as broad as the abdomen, almost isometrical. The anterior thighs are strongly inflated, and frequently dentated in the males. The tibiæ are long and narrow. The terminal article of the antennæ is ovoid-conic, and elongated. The species are peculiar to the western countries of the ancient continent, and are confined to its warmer parts. In SCOTOBIUS of Germar, the terminal article of the antennæ is scarcely longer than the preceding, and in the form of a reversed top. The thorax is perceptibly broader than long, and much arched in its lateral margins. These insects are peculiar to South America.

Other insects of this tribe, agreeing with those just named in the entireness of the mentum, are remarkable for the lateral dilatations or tooth-like projections of the thorax. The eyes are more projecting than in the others, and the antennæ are pubescent. The elytra are very unequal. Such is the genus SEPIDIUM[10] of Fab. of which the species are found in the southern countries of Europe, and in Africa.

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[1] *Ann. des Sciences Nat.* v. p. 276.

[2] *Ibid.* iii. p. 478.

[3] *Observ. sur les usages des diverses parties du tube intestinal des Insectes. Ann. du Mus.*

[4] From Πιμελης, *fat.*

[5] For the new generic divisions of *Pimelia* of Fabricius, see *Règne Animal*, v. p. 5–7.

[6] From Ζοφωσῖς, *obscurity.*

[7] From ἄκις, *a javelin.*

[8] From 'Ευρυχῶρος, *wide.*

[9] From Σκαυρος, *having projecting claws.*

[10] From Σηπίδιον, *putridity.*

Coleoptera Hetero-mera.

Among the last to which we shall here allude, is the genus TRACHYNOTUS, Lat. (Plate CCXXV. fig. 26), which differs from the preceding in the joints of the antennæ: these are mostly cylindrical, or in the form of an elongated and reversed cone, the last three or four being alone rounded, and either ovoid, turbinated, or hemispherical. The eyes are almost round or oval, entire, or but slightly emarginate, and elevated. The last article of the antennæ is sensibly longer and thicker than the preceding.

In the genus MOLURIS, Lat. *Psammodes*, Kirby (Plate CCXXV. fig. 27), the eyes are narrow and elongated, and scarcely elevated. The thorax is convex, nearly orbicular, emarginate in front, truncated posteriorly, and without angular dilatations on the sides. These insects, in common with those immediately preceding, occur at the Cape.

TRIBE 2D, BLAPSIDES, Lat.

This tribe receives its name from the genus *Blaps* of Fabricius. The maxillary palpi are terminated by an obviously dilated article, triangular or hatchet-shaped. Among other anatomical observations made by M. Dufour in relation to these insects, he states that they are provided with a double excrementitial secreting apparatus, totally different in structure from that of the pentamerous tribes. It consists of two tolerably large oblong bladders, placed altogether beneath the viscera of digestion and generation, closely approximated to each other, with extremely thin parietes, and surrounded by vascular folds, adherent, more or less pursed or turgid, and of which it is difficult to ascertain the precise point of insertion, from the impossibility of unrolling them. The same may be said of the canals destined to the emission of the secreted fluids. They are concealed by a kind of membranous diaphragm, which is applied, by means of a fleshy pannicle, to the last ventrical segment. The fluid flows out laterally, and not from the extremity of the terminal segment: it is of a brownish colour, extremely acrid and irritating, of a peculiar and penetrating odour, and is capable of being thrown to a distance of six or eight inches.

Those in which the body is generally oblong, with the abdomen laterally embraced by the elytra, and in which these parts are frequently narrowed towards the end, and terminate in a tail-like point, form Latreille's first division. The tarsi are nearly alike in both sexes, and without any remarkable dilatation. In the genus ACANTHOMERA, Lat. (Plate CCXXVI. fig. 2), the thorax is almost orbicular, transversal; the abdomen nearly globular; the third article of the antennæ cylindrical, and longer than the ensuing. In BLAPS[1] proper (Plate CCXXVI. fig. 27) the thorax is almost square, and plane or but slightly convex. The abdomen is oval, transversely truncate at the base, more or less elongated. The elytra, for the most part, are narrowed or prolonged to a point, especially in the males. The third article of the antennæ is cylindrical, and much longer than the ensuing; the last is short and ovoid. As an example of this genus (of which there are three British species), we may name a well-known insect, *B. mortisaga* (ibid.) nearly an inch long, of a somewhat shining black, the ends of the elytra forming an obtuse point. It occurs occasionally in pantries, store-rooms, and other parts of houses, especially such as are dirty or neglected. A species called *Blaps sulcata* is said by Fabricius to be eaten by the Turkish women in Egypt, to make them fat. They cook it with butter. On the same authority, it is asserted to be used as a cure for headach and the sting of the scorpion. In SCOTINUS of Kirby (Plate CCXXVI. fig. 9),[2] the thorax is emarginate and dilated at the anterior corners, and the terminal joints of the antennæ are thickened, the two last being confounded together.

Then follow certain Blapsides with an oval and slightly elongated body, and farther distinguished by a sexual difference in the tarsi, the first or the two anterior pair being most dilated in the males, and their inferior surface usually silky, or furnished with a brush. These insects frequent sandy places. Their two anterior tibiæ are generally wider, dilated triangularly at the extremity, and adapted for digging. Here are placed the genera *Pedinus*, *Blaptinus*, &c. of Latreille, Dejean, and other authors.[3]

TRIBE 3D, TENEBRIONITES, Lat.

These differ from the last in being provided with wings. Their body is usually oval or oblong, depressed or but slightly raised, with the thorax square or trapezoidal, and as wide as the abdomen at its posterior extremity. The palpi are larger at their extremity; the last joint of the maxillary palpi has the form of a reversed triangle, or is hatchet-shaped: the mentum is but slightly widened, and leaves the base of the maxillæ exposed. The genus *Tenebrio*, as originally arranged by Fabricius, together with *Opatrum* and *Orthocerus*, serve in this tribe as the types of as many divisions.

1*st*, Those in which the body is oval, with the thorax nearly trapezoidal, arcuated laterally, or forming a semioval truncated anteriorly, wider than the abdomen, at least at its posterior margin, but slightly, if at all, bordered; the maxillary palpi terminated by a securiform joint, or nearly resembling that form; the antennæ insensibly enlarged. Here are placed the genera CRYPTICUS of Lat. and OPATRUM, Fabricius.

2*d*, Those in which the body is narrow and elongated, almost of equal breadth posteriorly, or wider, with the thorax nearly square, and at least almost as long as it is broad; the antennæ forming a thickish club, or abruptly dilated at the extremity. Such are, among others, the genera CORTICUS of Dejean (Plate CCXXVI. fig. 13), ORTHOCERUS, Lat. (ibid. fig. 25), and CHIROSCELIS of Lamarck (ibid. fig. 32).

3*d*, Those of which the body is equally narrow and elongated, with the thorax nearly square, but of which the antennæ are of the ordinary thickness, and not abruptly terminated by a mass or club. In UPIS, Lat. (Plate CCXXVI. fig. 5), the thorax forms a lengthened square; the body is narrow, though not linear; the penultimate joints of the antennæ are lenticular and transversal. In TENEBRIO[4] properly so called (ibid. fig. 23), the thorax differs from that of Upis in being broader than long. *T. molitor* (the species figured) is a well-known insect, which appears in the evening in the least frequented parts of houses. It is likewise found in flour-mills, bakehouses, and among old walls. Its larva, commonly called the meal-worm (ibid. fig. 29), is long, cylindrical, of an ochry yellow, scaly in its texture, and smooth. It lives among bran and flour, and forms a favourite and judicious food for nightingales in the domestic state. It sometimes occurs in the interior of the human body. How it gets there nobody seems to know, but the fact is certain. We have three or four species of the genus in Britain. In a singular genus, named HETEROTARSUS[1] by Latreille (Plate CCXXVI. fig. 30), the penultimate joint of the tarsi is extremely small, in the form of a little knob, and received into a longitudinal groove of that which precedes it, which is itself more dilated, and almost cordiform (ibid. figs. 34 and 36). The only species with which we are acquainted comes from Senegal. It has all the characters of a Tenebrio, with the exception of its remarkable tarsi. At first sight the two anterior seem to consist but of four joints, and the two others of three. See the figures last referred to.

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[1] From Βλαξ, *slow*.

[2] Owing to the accidental omission, by the engraver, of several figures, which were afterwards inserted in the vacant spaces, some of the subjects of Plate CCXXVI. are by no means in systematic order; but the references in the text will be found correct.

[3] See *Règne Animal*, t. iv. p. 456.

[4] The name refers to the habits of the species, and signifies one that shuns the light.

FAMILY II.—TAXICORNES, LAT.

In this family the small corneous tooth on the inner side of the maxillæ, mentioned in our generalities of the preceding tribes, is wanting. All the species are winged. Their body is generally square, their thorax trapezoidal or semicircular, and either concealing or receiving the head. The antennæ, usually inserted beneath a marginal projection of the sides of the head, are short, more or less perfoliate or granose, and either enlarge insensibly or terminate in a club. The legs are not adapted for running, and all the articles of the tarsi are entire, and terminated by simple hooks; the anterior tibiæ are often broad and triangular. Several males have the head furnished with horns. The greater proportion of these Heteromera occur on tree fungi, or beneath the bark; some live on the ground under stones. M. Dufour has observed an excrementitial secreting apparatus in several genera, and salivary vessels are known to exist in the genus *Diaperis.* The chylific ventricle is beset with little hair-like papillæ.

In some the head is exposed, and never entirely received into a deep anterior notch of the thorax. The latter portion is sometimes trapezoidal or square, sometimes almost cylindrical; its margins, as well as those of the elytra, do not extend perceptibly beyond the body. This division forms

TRIBE 1ST, DIAPERALES, Lat.

In the genus DIAPERIS properly so called[2] (Plate CCXXVI. fig. 1), the maxillary palpi terminate in an article scarcely thicker than the preceding, and nearly cylindrical; the anterior tibiæ, scarcely, if at all, larger than the following, are narrow, almost linear, and feebly dilated at their extremity. Among the ovoid and convex species, with the central portion of the thorax lobate posteriorly, we may name the insect here figured, *D. boleti.* Its body measures about three or four lines in length; it is of a shining black, with three bands of fulvous yellow, transverse and dentated, upon the elytra. It is a well-known British species, not yet observed in Scotland. In LEIODES of Lat. (*Anisotoma* of Fab.) the body is short and convex, and the antennæ terminate in an oval mass of five joints, of which the second is the least. Mr Stephens enumerates above thirty British species, of which *L. arenaria* was lately discovered near Cramond Bridge, Edinburgh.[3] In this tribe are contained several other genera of minute insects, such as *Tetratoma*, Herbst, *Eledona*, Lat. &c.

TRIBE 2D, COSSYPHENES, Lat.

These are analogous in form to the genus *Peltis* of Fab. and to several Nitidulæ and Cassidæ. They are ovoid or sub-hemispherical, and overlapped in their contour by the dilated sides of the thorax and elytra. The head is in some entirely concealed beneath the thorax,—in others it is received or incased in its anterior emargination. The last joint of the maxillary palpi is larger than the preceding ones, and hatchet-shaped. This tribe corresponds to the unrestricted genus COSSYPHUS of Olivier and Fabricius.

In the genus COSSYPHUS properly so called (Plate CCXXVI. fig. 3), the thorax is almost semicircular, exhibits no anterior emargination, and entirely covers and conceals the head. The antennæ are short, terminate abruptly in an oval mass of four articles, chiefly transversal: the second of the whole number and the following ones are almost identical. These insects inhabit the East Indies, the south of Europe, and the north of Africa. In HELÆUS of Lat. and Kirby, the head is received into a deep emargination, or median aperture of the thorax, and is exposed at least superiorly. The antennæ terminate gradually in a narrow elongated club. These insects are peculiar to New Holland. Some other species, proper to South America, of which the body is almost hemispherical, very convex, and of a soft or slightly solid consistence, form the genus NILIO of Lat. At first sight they remind one of Coccinellæ, and of various species of Erotyli.

FAMILY III.—STENELYTRA,[4] LAT.

This family of heteromerous Coleoptera differs from the preceding one chiefly in the antennæ, which are neither granose nor perfoliated. In the greater number the extremity is not thickened. The body is generally oblong, arcuated above, and the legs elongated, as in many other insects. The males, except in their antennæ and general dimensions, resemble the females. Our present species generally are of much more active habits than those we have just left. Many conceal themselves beneath the bark of trees, while most of the others are met with on flowers and foliage. Linnæus referred most of them to his genus *Tenebrio*, and distributed the remainder among the incongruous groups of *Necydalis*, *Chrysomela*, *Cerambyx*, and *Cantharis.* In the first edition of the *Règne Animal*, Latreille combined them under a single genus, that of *Helops;* but a more intimate knowledge of their structure, interior as well as exterior, has since induced him to partition them into five tribes, referable to a corresponding number of the older genera, viz. *Helops*, *Cistela*, *Dircæa*, of Fab. and *Œdemera* and *Mycterus* of Olivier. In *Œdemera* the head is more or less narrowed, and prolonged anteriorly in the form of a muzzle, and the penultimate article of the tarsi is always bilobed,—a character which seems to connect these insects with the weevils, or rhyncophorous Coleoptera. In respect to the digestive canal, and some other considerations, *Helops* and *Cistela* approach the Tenebriones; but in Cistela the chylific ventricle is smooth, and the mandibles entire, and the species affect flowers and leaves, a habit by which they are distinguished from Helops. Most of the Dirceæ possess the faculty of leaping, and the penultimate article of the tarsi, or at least of some of them, is bifid. Some live in mushrooms, others in old wood. They connect on one side with He-

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[1] From ἕτερος, *different*, and ταρσος, *a part of the foot or hand.*

[2] From διαπειρω, *to pierce through.*

[3] *Entomologia Edinensis*, p. 145. We also possess an undescribed species, from the same locality, named in our cabinet *L. fuscicollis.*

[4] From στενος, *narrow*, and ελυτρον, *sheath*, in reference to the form of the elytra.

Coleoptera Heteromera.

lops, and on the other with Œdemera, and still more with that sub-genus of the same tribe named *Nothus* by Ziegler. These are the principles by which Latreille has been recently directed in his arrangement of the present family.

A certain number (including the first four tribes) have the antennæ approximate to the eyes, and the head not prolonged into a trunk, but terminated at most by a short muzzle.

TRIBE 1ST, HELOPII.

Antennæ covered at their insertion by the margins of the head, almost filiform, or a little larger towards the extremity, generally composed of nearly cylindrical articles attenuated towards the base, and of which the penultimate are frequently a little shorter, in the form of a reversed cone,—the terminal being for the most part nearly ovoid, and the third always lengthened. The extremity of the mandibles is bifid; the last joint of the maxillary palpi is of larger size, and hatchet-shaped, or in the form of a reversed triangle. The eyes are oblong, reniform, or emarginate. None of the legs are adapted for leaping; the penultimate joint of the tarsi, or at least of the hindmost ones, is almost always entire, or not deeply bilobed; the terminal hooks are simple, or without fissure or dentation. The body is for the most part arcuated above, and always of a firm and solid consistence. Such of the larvæ as are known are filiform, smooth, shining, with very short feet, like those of the Tenebriones. They occur in old wood. It is also beneath the bark of ancient trees that we find the perfect insects. The tribe corresponds in great part to the genus *Helops* of Fabricius.

Some have the body almost elliptical, strongly arcuated above, or very convex, with the antennæ at the utmost as long as the thorax, compressed and dilated towards their extremity, like the teeth of a saw; the thorax transversal, plane above, either trapezoidal and widening posteriorly, or almost square; the elytra frequently terminated by a point or tooth. The posterior extremity of the præsternum forms a little salient point, which is received by a forked notch of the mesosternum. Here are placed the genera EPITRAGUS and CNODALON of Lat. and CAMPSIA of Lepelletier and Serville.

In all the other Helopii, the mesosternum exhibits no marked emargination, and the posterior extremity of the præsternum is not prolonged to a point. Here are placed the genera SPHENISCUS of Kirby, ACANTHOPUS of Megerle and Dejean, AMARYGMUS of Dalman, SPHÆROTUS and ADELIUM of Kirby, and HELOPS properly so called. In the last named, most of the joints of the antennæ are nearly in the form of a reversed cone, or cylindrical and attenuated at the base. The thorax is transverse, or scarcely as long as broad, either square, or trapezoidal, or heart-shaped, abruptly narrowed posteriorly, terminated by pointed angles, and always applied exactly to the base of the elytra. Here also are placed the genera LÆNA of Megerle, STENOTRACHELUS, STRONGYLIUM of Kirby, and PYTHO of Latreille.[1]

TRIBE 2D, CISTELIDES.

This is very closely allied to the preceding, but the insertion of the antennæ is not covered. The mandibles terminate in an entire point, or are unemarginate. The hooks of the tarsi are dentated beneath like the teeth of a comb. Several of these insects live on flowers. Their digestive canal is shorter than that of the Helopii, and the chylific ventricle exhibits no papillæ. They correspond to the genus *Cistela* of Fabricius.

In some all the articles of the tarsi are entire. The last joint of the maxillary palpi is simply a little larger, obconical or triangular. In LYSTRONICHUS, Lat., the thorax is thick, narrower than the abdomen, almost orbicular or heart-shaped. The antennæ are thickened towards the extremity. The thighs are clubbed. In CISTELA properly so called, the thorax is depressed, trapezoidal, of the breadth of the abdomen at its posterior margin, or scarcely narrower. The antennæ are filiform, or slightly enlarged at the extremity, and the head is advanced in the manner of a muzzle. In others, such as the genus *Allecula*, Fab., the penultimate article of the tarsi is bilobed, and the last joint of the maxillary palpi much dilated, in the form of a hatchet. The body is generally more oblong.

TRIBE 3D, SERROPALPIDES.

The most remarkable distinction of this tribe, and that from which it derives its name, is the frequent serration of the maxillary palpi, which are likewise large and inclined. The antennæ are inserted in an emargination of the eyes, exposed as in the preceding tribe, and often short and filiform. The mandibles are emarginate or bifid at the extremity, and the hooks of the tarsi are simple. The body is almost cylindrical in some, oval in others, with the head inclined and the thorax trapezoidal. The anterior extremity of the head is not advanced, and the posterior thighs are not inflated. The penultimate article of the tarsi, or at least of the four anterior, is frequently bilobed; and in those in which it is entire the posterior legs at least are adapted for leaping; they are thin, long, compressed, the tarsi small, almost setaceous, with the first article elongated. The anterior are always short and dilated. The genus *Dircæa* of Fabricius forms the type of the tribe. It contains the genera ORCHESIA, Lat., EUSTROPHUS, Illiger, HALLOMENUS, Paykul, DIRCÆA (proper), Fab., MELANDRYA, Fab., HYPULUS, Paykul, SERROPALPUS, Hellw., and CONOPALPUS, Gyll.

TRIBE 4TH, ŒDEMERITES.[2]

This tribe is allied to the preceding by several characters, such as the exposed insertion of the antennæ near the eyes, the bifid extremity of the mandibles, the bilobation of the penultimate article of the tarsi, and the hatchet shape of the terminal joint of the maxillary palpi; but they exhibit other characters, which authorize their separation. The body is elongated, narrow, almost linear, with the head and thorax scarcely so broad as the abdomen; the antennæ are longer than those parts, serrated in some (such as *Calopus*), filiform or setaceous, and composed of long and nearly cylindrical articles, in others. The anterior extremity of the head is more or less prolonged in the form of a small muzzle, and rather restricted behind, with the eyes proportionally more elevated than among the preceding tribes. The thorax is at least as long as wide, and a little narrowed behind. The elytra are linear, or narrowed posteriorly, and are frequently flexible. Latreille regards the species as allied to *Telephorus* and *Zonitis*. M. Dufour has recognised in the Œdemerites the existence of salivary vessels, of a simple nature, flexuous and floating, as well as of a paunch formed by a lateral crop, furnished with a neck or pedicle.

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[1] For the details of these and other genera of the tribe which we have been unable to do more than name, we must refer the reader to Latreille's *Genera Crustac. et Insect.*; the *Encyclop. Méthod.*; *Linn. Trans.* vol. xii.; Dalman's *Analecta Entomol.*; Dejean's *Catalogue*, and Fischer's *Entomog. de la Russie*.

[2] From οιδιῶ, *I swell*, and μερος, *thigh*.

They are the only Coleoptera in which that character has been observed. These insects, of which the transformations are unknown, are found on flowers and trees. They are all comprised in the old genus *Œdemera* of Olivier.

In some the antennæ are always short, inserted in a notch of the eyes, and simple; the posterior thighs are inflated, at least in one of the sexes; the thorax as broad as the base of the abdomen; and the hooks of the tarsi bifid. Such is the genus NOTHUS of Ziegler, in which the maxillary palpi are terminated by a large elongated hatchet-shaped article. The posterior legs in one of the sexes are very large, and furnished beneath with a strong tooth and two little spurs, near the lower extremity of the tibiæ. The head is not prolonged anteriorly.

In others the antennæ are always longer than the head and thorax, the legs usually of nearly equal size, the thorax narrower than the base of the abdomen, slightly narrowed posteriorly, and the hooks of the tarsi entire. Such are CALOPUS, Fab. SPAREDRUS, Megerle, DYTILUS, Fisch. and ŒDEMERA properly so called (Plate CCXXVI. fig. 4).

TRIBE 5TH, RHYNCHOSTOMA.[1]

In this, which forms the concluding tribe of the Stenelytra, are grouped certain insects, some of which are evidently allied to the preceding, while others in a natural system might be regarded as belonging to the *Rhyncophori.* The head is obviously prolonged anteriorly in the form of an elongated muzzle, or of a flattened trunk, bearing the antennæ at its base, and in advance of the eyes, which are always entire or without emargination.

Sometimes the antennæ are filiform, and the muzzle not enlarged at the base; the thorax is narrowed in front in form of a truncated cone or of a trapezium; the ligula is emarginate, and the terminal joint of the tarsi bilobed. These insects occur on flowers, a habitat indicated by the silky prolongation of the terminal lobe of the maxillæ. Such are the genera STENOSTOMA, Fab. and MYCTERUS, Clairville.

Sometimes the antennæ are terminated by an elongated mass, formed by from three to five terminal joints; the muzzle is very flat, with a projecting angle on each side, anterior to the extremity; the thorax is in the form of a truncated heart, narrowed posteriorly; the ligula and all the joints of the tarsi are entire. These insects dwell beneath the bark of trees, and seem allied to the *Anthribi* of Fabricius. They form the genus RHINOSIMUS of Lat. and Oliv. Those of which the club of the antennæ consists of only three articles, fall under the genus SALPINGUS of Illiger. We have several British species.

The second general division of heteromerous Coleoptera forms

FAMILY IV.—TRACHELIDES.

The head is triangular or heart-shaped, borne upon a kind of neck or abrupt pedicle; the body is usually soft; the elytra flexible, without striæ, sometimes very short, in others slightly inclined. The maxillæ are not unguiculated. The joints of the tarsi are often entire, and the hooks of the posterior ones bifid. The majority of these insects live in the perfect state on various plants, of which they devour the foliage, or suck the nectarous juices. Many, when seized, bend their heads, contract their limbs, and simulate death. Others are extremely active. Latreille divides them into six tribes.

TRIBE 1ST, LAGRIARIÆ.

These have the body elongated, and narrower in front; the thorax either almost cylindrical or square, or ovoid and truncated. The antennæ, inserted near a notch on the eyes, are simple, filiform, or insensibly increasing towards the extremity, generally and at least partially granose, with the terminal article longer than the preceding in the males. The palpi are thickened at their extremity, and the terminal joint of the maxillary is larger, and in the form of a reversed triangle. The thighs are oval and clubbed; the tibiæ elongated, narrow, with at least the two anterior arched. The penultimate article of the tarsi is bilobed, and the hooks of the last are neither incised nor dentated. The tribe is formed of the genus LAGRIA of Fabricius, subdivided in accordance with certain characters detailed in the *Règne Animal*, t. v. p. 52.

TRIBE 2D, PYROCHROIDES,

Approach the preceding in regard to the tarsi and the elongation and restriction of the anterior part of the body,—but the latter is flattened, with the thorax almost orbicular or trapezoidal. The antennæ, at least in the males, are pectinated or plumose—*en panache;* the maxillary palpi are somewhat toothed or serrated, and terminate in an elongated and almost hatchet-shaped article; the labial palpi are filiform. The abdomen is elongated, entirely covered by the elytra, and rounded at the end. These insects are found in woods in spring. The larvæ dwell beneath the bark of trees.

In the genus DENDROIDES, Lat. the antennæ of the males are almost as long as the body, and give off long bearded filaments; in the same sex the eyes are large, and approximated behind. The thorax is trapezoidal, or in the form of a truncated cone; and the body, as well as the legs, is proportionally more elongated. In the genus PYROCHROA properly so called[2] (Plate CCXXVI. fig. 6), the antennæ are shorter and simply pectinated, the eyes distant, and the thorax almost orbicular and transversal.

TRIBE 3D, MORDELLONÆ.

These do not present, either in relation to the form of the tarsi and their hooks, or to that of the antennæ, any constant character in common, but they are easily distinguished from the other Heteromera of the same family by the general conformation of their body. It is elevated, and arcuated; the head is low, the thorax trapezoidal or semicircular, and the elytra either very short, or narrowed, and terminated by a point, as well as the abdomen. Several of these insects approach the Pyrochroides in respect to their antennæ;—others in their maxillæ, the hooks of the tarsi, and their parasitical habits, resemble *Nemognathus* and *Sitaris,* two genera of an ensuing tribe;—but they differ from all of these in their extreme agility, and the firm and solid consistence of their teguments. They formed the old genus *Mordella* of Linn.

Some have the palpi almost of the same thickness throughout. The antennæ of the males are strongly pectinated or fan-like. The extremity of the mandibles offers no emargination. The articles of the tarsi are always entire, and the hooks of the hindmost are dentated or bifid. The middle of the posterior margin of the thorax is always much prolonged backwards, like a scutellum. The eyes are unemarginate. The larvæ of certain species (*Ripiphori*) live in the nests of wasps.

The genus RIPIPHORUS of Bosc (Plate CCXXVI. fig. 7) has the wings extended, and reaching beyond the elytra, which equal the length of the abdomen. The hooks of the tarsi are bifid. The antennæ, inserted near the inner edge of the eyes, are pectinated on both sides in the males,—serrated, or with only a single range of short teeth, in the females. The terminal lobe of the maxillæ is very long, linear, and projecting; and the ligula is also elongated, and deeply bifid. Some naturalists having found in the nest of the common wasp several living specimens of *R. paradoxus*, it has been inferred that they live there in the larva state. M. Farines, however, has observed that the larva of *R. bimaculatus* lives and undergoes its transformations in the roots of *Eryngium campestre*.[1] Here are placed the genera PELOCOTOMA of Fischer, and MYODITES of Lat.

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[1] From ϱυνχος, *beak*, and στόμα, *mouth.*

[2] From πυϱ, *fire*, and ωχϱος, *yellow.*

Others have the wings always covered by the elytra, which are prolonged nearly to the extremity of the abdomen, and terminate in a point. The posterior margin of the thorax is slightly if at all lobed. The abdomen of the females is terminated by a pointed tall. The eyes are sometimes emarginate. The maxillary palpi are terminated by a large article, in the form of a hatchet or reversed triangle. The extremity of the mandibles is notched or bifid. The antennæ, even in the males, are merely serrated. In MORDELLA properly so called (Plate CCXXVI. fig. 8), the antennæ, of equal size throughout, are slightly serrated in the males. All the articles of the tarsi are entire, and the hooks of the last present beneath one or two small indentations. M. Dufour has observed in a species of this genus two floating salivary vessels, longer than the body. The hepatic vessels have no cæcal insertion,—an exceptive character in the present section. The genus ANASPIS,[2] Geoff. is distinguished from the preceding by the antennæ, which are simple, and gradually enlarged, by the emargination of the eyes, and by the four anterior tarsi, of which the penultimate article is bilobed. The hooks of the last are entire and without sensible dentations.

TRIBE 4TH, ANTHICIDES.

Here the antennæ are simple, or slightly serrate, filiform, or a little thicker towards the end, and most of the articles are in the form of a reversed cone, and nearly alike, except the last (and sometimes also the two preceding), which is larger and oval. The maxillary palpi are terminated by a securiform club. The penultimate joint of the tarsi is bilobed. The body is narrow anteriorly, with the eyes entire or slightly emarginate. The thorax is sometimes in the form of a reversed oval, narrowed and truncated posteriorly, sometimes divided into two knots, in others semicircular. Certain species are found on plants of different kinds, but the majority occur upon the ground. They run with great swiftness, and their larvæ have been supposed to be parasitical. They compose the genus NOTOXUS[3] of Geoffroy, which Latreille divides into SERAPTIA, STEROPIS, and NOTOXUS properly so called.[4]

The two concluding tribes of this family, and of the heteromerous section, exhibit certain characters in common, such as the termination of the mandibles in a simple point, the palpi filiform or simply a little longer at their extremity, but never either clubbed or securiform, the abdomen soft, the elytra flexible, and in most instances blistering or vesicatorial, and, with few exceptions, the articles of the tarsi entire, and the hooks of these parts generally bifid. They are all herbivorous in the perfect state, but many are parasitical, while larvæ, in the dwellings of other tribes.

TRIBE 5TH, HORIALES.

These differ from the ensuing, or Cantharidiæ, in their hooks, which are dentated, and each accompanied by a serrated appendage. The antennæ are filiform, not longer than the thorax; the labrum is small, the mandibles strong and projecting, the palpi filiform, the thorax square, and the two posterior legs very robust, at least in one of the sexes. The tribe is composed of the genus HORIA of Fabricius (Plate CCXXVI. fig. 10). These insects inhabit the intratropical regions of India and America. The lamented Lansdown Guilding has published figures and a short history of *H. maculata*.[5] It deposits its eggs in the nest of a wood-gnawing bee (*Xylocopa teredo*), and the larvæ, when hatched, are supposed to devour the food deposited in the ligneous chambers for a very different purpose by the parent bee. "Forsan," says Mr Guilding, "dum larva cibum apibus præparatum avide consumit, hospes fame perit." It is often so.

TRIBE 6TH, CANTHARIDIÆ.

This tribe is distinguished from the preceding by the hooks of the tarsi, which are deeply divided, and appear as if double. The head is generally large, broader, and rounded posteriorly. The thorax is usually narrowed behind, and approaches the form of a truncated heart; in some it is almost orbicular. The elytra are often somewhat inclined laterally, or tectiform, and rounded. These insects counterfeit death when seized, and several of them exude a yellow caustic liquor, of a penetrating odour, from the joints of their antennæ; but no peculiar apparatus for the production of that secretion has yet been ascertained. Many kinds are highly serviceable in the formation of blistering applications. They were all included originally in the old genus MELOE of Linnæus, now greatly subdivided. The anatomical observations of M. Dufour, and the extremely interesting researches of M. Bretonneau of Tours, on the vesicatorial properties of this tribe of insects, have enabled Latreille to arrange them in what he regards as a natural order,—not greatly differing, however, from that which he had previously adopted. M. Bretonneau has ascertained that the genus *Sitaris* is not vesicatorial,—and M. Dufour has found that these same Heteromera possess only four biliary vessels instead of six, the amount by which other insects of the tribe are characterized. That genus also resembles *Zonitis* in its general organization, while the latter is itself closely allied to *Cantharis*. The series of groups adopted by Latreille is also in harmony with the progressive changes in the form of the antennæ.

In some these organs are composed in both sexes of only nine articulations, of which the last is large, and in the form of an ovoid head; those of the males, as well as their maxillary palpi, being very irregular. The body is depressed. Such is the genus CEROCOMA of Geoff. The species make their appearance during the summer solstice, and frequently in great numbers on the same spot. They frequent the flowers of the wild chamomile, milfoil, &c. *Meloe Schæfferi* of Linn. of a bluish green, with the antennæ and legs wax yellow, may be mentioned as an example.

In all the others the palpi are identical and regular in both sexes. The antennæ have generally eleven articulations, and when they offer one or two less they terminate regularly in a club. The body is thickish, and the elytra somewhat inclined.

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[1] *Annales des Sciences Nat.* viii. 224; and *Nouv. Dict. d'Hist. Nat.* second edition, art. *Ripiphore.*

[2] From α priv. and ασπις, *scutellum.*

[3] From νοτος, *back*, and οξυς, *pointed.*

[4] See *Règne Animal*, t. v. p. 58; and *Mém. des Nat. de Moscou*, i. 166.

[5] *Linn. Trans.* vol. xiv. part ii. p. 315.

In some the antennæ, always regular and granose in both sexes, sometimes appear to be composed of only from nine to ten joints, and are not longer than half the body; they occasionally terminate in an arcuated club, or are obviously enlarged at the extremity; while in others they form from the second joint a short cylindrical or almost fusiform stem. They constitute the genus *Mylabris* of Fabricius. Such of them as have the two or three last joints of the antennæ united, at least in the females, and forming an abrupt, thick, ovoid, or button-shaped club, the extremity of which does not extend beyond the thorax, and in which the total joints are only from nine to ten, form the genus Hycleus of Lat. Such, again, as have the antennæ proportionally longer, and offering in both sexes eleven distinct and well-divided articulations, gradually enlarging, or terminating by degrees in an elongated club, of which the terminal joint, very distinguishable from the preceding, is large and ovoid, belong to the genus Mylabris properly so called (Plate CCXXVI. fig. 11). The species we have here represented is the *M. chicorii.* It is more than half an inch long, black, pilose, with an almost round yellowish spot on the base of each elytron, and two transverse and indented bands of the same colour, one near the centre, and the other nearer the extremity. The antennæ are black. This insect, unknown in Britain, is occasionally found as far north as the vicinity of Paris, but it is much more common in the south of France, and other meridional parts of Europe. Its blistering qualities are quite as active and efficient as those of the true *Cantharis* or Spanish fly; and in Italy it is employed for the same purposes, mixed up with the latter, or even used alone. *M. pustulatus* is used by the Chinese.

In the other Heteromera of this tribe the antennæ, always composed of eleven very distinct joints, are almost of equal thickness throughout, or rather more slender towards the extremity, and frequently much longer than the head and thorax. They are irregular in several males. In Meloe properly so called (Plate CCXXVI. fig. 12), the antennæ are composed of short and rounded joints, the intermediate of which are the largest, and sometimes so disposed that these parts in the males exhibit an emargination or crescent-like form. The wings are wanting, and the elytra, oval or triangular, with a portion of the inner margins crossing each other, only partially cover the abdomen, especially that of the females, which, as often happens, is extremely voluminous. According to Dufour, the crop of these insects may be considered as a true gizzard, being furnished internally with callous and anastomosing plicæ, and separated from the stomach or chylific ventricle by a valve formed of four principal pieces, each of which results from two hollow cylinders placed back to back, and tridentated posteriorly.

All the species of the genus Meloe are awkward and mis-shapen, and of sluggish movements. They are found either crawling slowly and heavily along the surface of the earth, or on plants of humble growth. They feed on leaves, and when handled, an oily fluid of a yellow or reddish colour flows from the joints of their legs. Latreille suspects that these insects are the *Buprestides* of the ancients, to which were attributed such destructive effects on cattle, when inadvertently swallowed by the latter. The genus seems characteristic of the European continent and islands. Eight or nine species occur in Britain; and of the twenty-one species enumerated by Dejean, the whole are European. Mr Kirby however possesses a specimen taken in North America by Professor Peck. They are all characterized by dark or sombre colours. They are most frequent in spring and autumn, and occur in fields and pathways, preferring, it is said, a sunny situation and a sandy soil. In some districts of Spain they are employed along with Cantharides, or in their room. They are also used by farriers.[1] The females, when filled with eggs, become greatly dilated, and in that condition much exceed the males in size. An individual of the former sex observed by Goëdart, and fed by him with the leaves of anemone and ranunculus, laid 2212 eggs between the 12th of May and the 12th of June, besides about as many more which were thrown aside uncounted. It effected this laying at two separate periods, placing the extremity of its abdomen in a hole which it had formed in the earth, and depositing the eggs in packets. These are of a yellowish colour, and resemble grains of sand pressed together. The larvæ are long, cylindrical, garnished with scattered hairs, composed of eleven nearly equal segments, besides the head, which is oval, and provided with two eyes, and a pair of longish antennæ. They have six legs, of rather large size compared with the length of the body, which is terminated by two long bristle-like appendices. Their larvæ are supposed by some ingenious observers to be parasitical on the bodies of winged insects. Degeer having remarked that a strong resemblance existed between the larvæ of Meloe, and a small insect which he found adhering to *Eristalis intricarius*, he placed two domestic flies among the former, and found that they were speedily adhered to by the larvæ, which stuck to them pertinaceously, and caused their death in two or three days. Bees are also subject to their attacks; and MM. Lepelletier and Serville are said to have recently confirmed the observations of Degeer, by breeding these parasites from the eggs of Meloe. "On the other hand," says Mr Curtis, "Mr Kirby is disposed to think that his *Pediculus Melittæ* (P. Apis, Linn.?) is not the larva of Meloe; and M. Leon Dufour has even formed them into a *genus* under the name of *Triungularis andrenetarum;* and a figure of one is given in the thirteenth volume of the *Annales des Sciences Naturelles.*"[2] M. Latreille seems to adopt the opinion of their parasitical nature; and the facts, so far as known, are well stated by M. Walkenaer, in his *Memoires pour servir à l'Histoire Naturelle des Halictes.*[3] The digestive system of the genus Meloe, with other anatomical details, has been illustrated by M. Dufour;[4] and we are indebted for a monograph of the British species to Dr Leach.[5]

All the ensuing genera of the tribe are provided with wings, and elytra, of the ordinary structure, covering longitudinally the back of the abdomen. In the genus **CANTHARIS**, Geoff. (Plate CCXXVI. fig. 14), all the joints of the tarsi are entire, the thorax almost ovoid, a little elongated, and restricted anteriorly, truncated posteriorly. The second joint of the antennæ is much shorter than the following, and the last of the maxillary palpi is sensibly larger than the preceding. The head is a little broader than the thorax. The antennæ of the males are sometimes irregular, and even semi-pectinated. The name of Cantharis is extremely ancient, and has been received in a variety of acceptations. Aristotle did not apply it to any particular insect, but to various Coleoptera.[1] Linnæus made use of the term to designate a great genus of the same order, which, however, did not include the true Cantharis, which he placed in *Meloe*. Geoffroy substituted the name *Cicindela*, already otherwise employed, for that of Cantharis, and placed in the latter the genuine Spanish fly. Fabricius placed it in his genus *Lytta*, which corresponds to Cantharis of Geoffroy. The latter, however, amidst all these revolutions of names, appears to have maintained its ground, and to have been the most generally adopted.

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[1] In regard to these insects we may further observe, that Dr Leach was informed by Mr Hunneman that the species called *M. variegatus* is highly prized in Germany as a medicine, being considered as a specific in hydrophobia. For this purpose it is taken by slipping a hair round its neck, and suspending it till dry; the oily secretion first thrown out being preserved, as in that the chief virtue is supposed to exist. Mr Hunneman adds more particularly, that the late king of Prussia, Frederick the Great, purchased the nostrum from the discoverer for a valuable consideration, as a specific against the bite of a mad dog. According to the recipe, twenty-five of these insects that have been preserved in honey, are, with two drachms of powdered black ebony, one drachm of Virginia snake-root, one ditto of lead filings, and twenty grains of fungus sorbi, to be reduced to a very fine substance; the whole, with two ounces of theriaca of Venice (and, *if necessary*, a little elder root), to be formed into an electuary! (See *Linn. Trans.* xi. p. 245.)

[2] *Brit. Ent.* vol. vi. fol. 279.

[3] See also *Introduction to Entomology*, vol. iv. p. 225.

[4] *Ann. des Sciences Nat.* t. iii. p. 486.

[5] *Linn. Trans.* xi. p. 35 and 242.

The Cantharides properly so called have an elongated and almost cylindrical form. The history of the most noted species, *C. vesicatoria*, commonly called the Spanish fly (fig. 14), is still somewhat doubtful, so far as concerns our knowledge of its transformations. Neither Degeer nor Geoffroy ever saw the larva. Those who suppose themselves to have seen it say that it feeds on various roots, and is metamorphosed in the earth,—an observation which accords with the usually sudden appearance of the perfect insect, the unexpected apparition of which has sometimes given rise to the belief that they migrated from more southern regions. It is described by Olivier as consisting, in its early state, of thirteen segments, soft, of a yellowish-white, with six short scaly feet,—the head rounded and flattish, and furnished with two short filiform antennæ. The mouth consists of a pair of tolerably solid maxillæ and four palpi. The medicinal uses of this now celebrated beetle are universally known, but its connection with the sanitory art is not traceable to a remote antiquity; for the Cantharis of the ancients was certainly not the same as the Spanish fly, and is even supposed to have belonged to a different genus. According to the testimony of Pliny and Dioscorides, who affirm that the best Cantharides are such as are marked with transverse yellow bands, it becomes evident that their species was the *Mylabris chicorii* already mentioned, which in China is used for epispastic preparations down to the present day. The insect of the European laboratories, *C. vesicatoria*, is of a beautiful golden green, with black antennæ. The males are less than the females, and there exists in general a great variety of size among different individuals. These insects are very common in France,[2] Italy, and Spain. The greater proportion employed in commerce come from the last-named country, and hence their common name. Their collection requires precaution on the part of those who are employed in that office, both with a view to guard against injurious accidents, and for the proper preservation of the objects themselves. They are killed by means of vapour of vinegar, and completely dried after they are dead. The following is the plan of procedure: In the course of the month of June the natives place extended cloths or sheets beneath the trees on which the Cantharides occur, and make them tumble down by beating all the branches. When they have obtained a considerable quantity, they either put them into a hair sieve, which they place over the vapour of vinegar, or into a fine cloth, which they dip repeatedly in a vessel containing diluted vinegar. They are then allowed to dry under the shade of some loft or granary, being placed on hurdles covered with cloth or paper, and stirred occasionally with a stick, or with the hand protected by a stout glove. When thoroughly dry they are packed into vessels of wood or glass, which are afterwards carefully and tightly closed. These little processes being properly attended to, the insects retain their blistering qualities for a length of time.

The chemical analysis of Cantharides has been made by numerous experimentalists, who appear, however, to have confined their researches rather too exclusively to the Spanish fly. Had they studied with equal assiduity the genera *Meloe* and *Mylabris*, and even *Carabus*, *Coccinella*, and several *Tenebriones*, they would have discovered in these also an analogous or identical principle, less active perhaps in its nature, but for that very reason susceptible of being employed with greater advantage in special cases. Thouvenet, Fourcroy, Beaupoil, Orfila, and especially Robiquet, have arrived at some remarkable results. The latter has demonstrated the existence of a particular substance, on which he has bestowed the name of *Cantharadine*, and which may be characterized as white, crystalline, insoluble in water, soluble in boiling alcohol, in ether, and in oils. It is the seat of the vesicatorial or blistering property, which does not therefore reside in the green oil, nor in the black insoluble matter, nor in the yellow matter soluble in alcohol and in water,—the other ingredients of which analysis has demonstrated the presence. This discovery, though important in a scientific point of view, has produced no alteration in the practice, which proceeds effectually enough upon the old experience, that when the substance of the insect is reduced to powder, mixed up with some fatty matter, and applied to the surface of the body, it immediately proceeds to action, and detaches the outer skin from the dermis with great rapidity. It is also used for several other purposes.[3] Naturalists are acquainted with many other species of Cantharis besides the Spanish fly. Of these we may mention *C. Syriaca* of Olivier, which occurs in Syria and the south of Europe, and the *C. dubia* of the same author, found in the southern provinces of France, Italy, the Levant, and Siberia. In the United States a species, described by Fabricius under the name of *vittata*, is employed for medicinal purposes. It is found in great abundance among potatoes.

The remaining genera of the tribe are **ZONITIS**, Fab. **NEMOGNATHUS**, Lat. **GNATHIUM**, Kirby, and **SITARIS**, Lat.

TETRAMERA.

Four Articulations to all the Tarsi.

The numerous and important groups which constitute this, the third primary section of the coleopterous order, are all vegetable feeders. The larvæ have very short

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[1] *Hist. Animal*, lib. iv. cap. 7.

[2] Latreille observes that they appear in France about the period of the summer solstice, and that they occur more particularly on the ash and lilac, on the leaves of which they feed. They diffuse around them a peculiar and highly penetrating odour.

[3] See *Annales des Sciences Nat.* ix. p. 31; and *Diction. Class. d'Hist. Nat.* iii. p. 156.

Coleoptera Tetramera.

feet, and in many even these seem wanting, or are replaced by mammillæ. The perfect insects occur among flowers and plants. Latreille divides them into seven families. The larvæ of the first four or five most commonly live concealed in the interior of plants, and are generally destitute of feet, or have these organs extremely small; many attack the hard or ligneous portion of their dwelling. These Coleoptera are the largest of their section.

FAMILY I.—RHYNCHOPHORA.[1]

This numerous and widely extended family, so remarkable for the beauty of its South American species, is easily recognised by its more or less extended muzzle, terminated by a mouth, of which the parts, from their peculiar structure and position, are not easily determined without the aid of microscopical examination and dissection. The abdomen is generally of a bulky form, the antennæ geniculate and clavate, and the penultimate joint of the tarsi almost always bilobate. In many tribes the posterior thighs are dentated. The body of the larvæ is oblong, and resembles a small white worm, exceedingly soft. The head is squamous or scaly, and the feet are either wanting or mammillæform. They live by gnawing the various parts of plants. Many dwell exclusively in the interior of fruits and seeds, and do great damage to the farmer, grain-dealer, and horticulturist. Some, such as the Brachyceri, are supposed to live beneath the ground, and to feed on roots.

The muzzle in this richly adorned family differs essentially from the *rostrum* of the hemipterous species. It is in fact merely a prolongation of the head, and not composed of the parts of the mouth, as in the last-named order. This prolongation, however, exerts an influence over the alimentary tube, the œsophagus being thereby somewhat prolonged, and—as we find to be the case in the truly suctorial tribes—there is also a provision of salivary glands.

We have little detailed information regarding the internal structure of the Curculionidæ. Two species (*Attelabus betuleti* and *Cryptorhynchus lapathi*) have been examined and described by Ramdhor.[2] In both of these the alimentary canal was moderately long, the stomach partially shaggy, and the small intestine inversely claviform. In other respects, however, they differed materially. There was no crop or gizzard in the former, the stomach was fringed on each side, except at its upper extremity, with a series of small cæca or shags, and there were three pair of bile-vessels; in the latter the gullet was dilated into a crop, which included a gizzard of singular and exquisite construction; for, though so minute as scarcely to exceed a large pin's head in size, it was found to be provided internally with more than four hundred pairs of teeth, moved by an infinitely greater number of muscles. A transverse section of this gizzard represented two concentric stars, with nine rays each, the object of this structure being the comminution of the timber which the insect has to perforate, and probably devour. The stomach was very slender, but dilated in the middle into a spherical vesicle; and only two pairs of bile vessels were observable.[3]

It may well be supposed, that in a family consisting of not much less than three thousand ascertained species, many diversities occur both in habit and external structure. The antennæ are sometimes straight, but more frequently have an angular bend. They are inserted either towards the extremity of the muzzle when that organ is short, or nearer the centre, or even towards the base, in the long snouted species. The number of the articulations of the antennæ varies in certain genera from six to ten; but eleven is the more usual number, or even twelve, if we count the false or terminal article. The body is generally narrowest in front, with a large abdomen covered by very hard elytra. The tarsi are very frequently garnished beneath with short hairs. None of the species are carnivorous in any degree; but even in the perfect state they are sometimes extremely noxious, when they happen, as they sometimes do, to occur in great abundance. They tap the buds and leaves of trees, and of several cultivated vegetables, and feed upon their juices.

TRIBE 1ST, BRUCHELÆ, Lat.

Labrum apparent, anterior elongation of the head short, broad, depressed, and in the form of a snout. Palpi very visible, filiform, or larger at the extremity. These insects compose the old genus *Bruchus*, Linn. They are subdivided as follows.

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[1] Since the publication of the first edition of the *Règne Animal*, considerable attention has been bestowed on this difficult family. Messrs Germar and Schœnherr, more particularly, have devoted their time to its elucidation; and the latter author (in his *Curculionidum Dispositio Methodica*, Leipsic, 1826) gives a hundred and ninety-four genera, exclusive of sub-genera. He divides the Curculionidæ, in accordance with the straightness or geniculation of their antennæ, into two great sections, the *Recticornes* or *Orthocera*, and *Fracticornes* or *Gonatocera*. The recent observations of M. Leon Dufour on the internal structure of these insects seem to strengthen the propriety of that classification. The species of the latter section are furnished with salivary vessels, which are wanting in those of the former. In Latreille's recent reconstruction of Schœnherr's arrangement, the Recticornes compose four tribes—the *Bruchelcs*, the *Anthribides*, the *Attelabides*, and the *Brentides*. In the first two the labrum and palpi are very visible; these palpi are filiform or larger at the extremity; they are small and conical in the two other tribes, as in all the following Rhynchophora. The Fracticornes form a fifth tribe, viz. the *Curculionites*. These are divided into the *Brevirostres* and the *Longirostres*, terms which bear relation to the place of insertion of the antennæ. In the former these organs are attached to the extremity of the muzzle, or on a line with the base of the mandibles,—while they are placed further back, or nearer the head, in the latter. The genera of the *Brevirostres* are arranged in three subtribes, viz. *Pachyrhyncides*, *Brachycerides*, and *Liparides*,—corresponding to the genera Curculio, Brachycerus, and Liparus of Olivier; the last sub-tribe comprising also some Lixi of that author. The relative size and form of the mentum, the mandibles, the presence or absence of wings, the direction of the lateral sulci of the proboscis, in which the first joint of the antennæ is partly lodged, the length of that joint, and the proportions and forms of the thorax—these and other secondary considerations furnish the characters of the various groups. The *Curculionites Longirostres* are divided into two principal sections, in accordance with their habits, and the composition of their antennæ. These consist, in the *Phyllophagi*, of not fewer than ten joints, the last three of which, at least, form the terminal club. But among the *Spermatophagi* the antennæ never consist of more than nine joints, of which the last or the last two form the club. The legs of the Phyllophagi are sometimes contiguous and sometimes remote. Those in which they approach each other are divided into four tribes:—the *Lixides* (Lixus, Fab.), the *Rhynchænides* (Rhynchænus, Oliv.), the *Cionides* (Cionus, Clairv.), and the *Orchestides* (Orchestes, Illig.). The *Spermatophagi*, again, form three principal sections or sub-tribes:—the *Calandræides* (Calandra, Clairv., Fab.), the *Cossonides* (Cossonus, Clairv.), and the *Dryopthorides* (Dryopthorus, Schœn., Bulbifer, Dej.). These latter lead to the *Hylesini*, Fab., and other Xylophagi. (See *Règne Animal*, t. v. p. 69.) A great proportion of the European Curculionidæ are most accurately described by Gyllenhal in his *Insecta Suecica*. Mr Kirby's paper on the genus *Apion* (Linn. Trans. vol. iv.) is also deservedly esteemed. The reader will find a critical and expository treatise on this family by Latreille, under the term RHYNCHOPHORES, of the *Dict. Class. d'Hist. Nat.* t. xiv. p. 584 He may also consult Germar's *Insectorum Species Novæ*, and the continuation of Illiger's *Magazin für Insectenkunde*. The British species are described, with their usual skill, by Messrs Curtis and Stephens. The latter, in the second edition of his *Nomenclature*, enumerates above 500 indigenous species. The Scottish kinds are described in our *Entomologia Edinensis*. We see, from our recent correspondence, that about 3000 species of this great family are now known to naturalists.

[2] *Abbildungen zur Anatomie der Insecten.*

[3] *Introduction to Entomology*, vol. iv. p. 107.

Those species of which the antennæ are clavate, or very obviously enlarged at their extremity, with the eyes unemarginate, and which appear to have five articulations to the four anterior tarsi, form the genus Rhinosimus, which Latreille, in accordance with its tarsal characters, formerly placed among the Heteromera, but which other natural affinities connect more closely with the following genus. Those of which the antennæ and eyes resemble the last, but which present only four tarsal articulations, compose the genus Anthribus[1] of Geoffroy and Fab. (Plate CCXXVI. fig. 16), to which Latreille adds the *Rhinomacers* of Olivier. These insects are generally found on old wood, although some occur on flowers. In the genus Bruchus properly so called[2] (Plate CCXXVI. fig. 17), the antennæ are filiform, frequently serrated or pectinated. The eyes are emarginate. The anus is exposed, and the hind legs are frequently very large. These species deposit their eggs in the yet tender germs of our leguminous plants, of our most valuable grains or palms, coffee, &c., where the excluded larvæ occasion infinite damage. The perfect insect detaches a portion of the epidermis in the form of a cap, and, on issuing, produces those circular holes so often seen on peas and beans. Such is a small species called *B. pisi* (see the figure last referred to), an insect which has been known to occasion great injury in North America. A very large species, the *B. Bactris* of Linn. occurs in Cayenne, where it feeds on the fruit of *Cocos guinensis*. It is named *Counana* by the natives. The genus Rhœbus of Fischer is distinguished from the preceding by flexible elytra and bifid hooks to the tarsi. The genus Xylophilus of Bonelli is characterized by clavate palpi.

In the other tribes there is no apparent labrum. The palpi are very small, inconspicuous to the naked eye, and of a conical form. The anterior prolongation of the head represents a beak or trunk.

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Sometimes the antennæ are straight or not geniculate (*Orthoceri*), inserted on the rostrum, and consist of nine or ten joints.

Those in which the three or four last joints are united into a club form

Tribe 2d, Attelabides, Lat.

They gnaw the leaves and tender parts of plants. Most of the females roll up these leaves into a tube or trumpet, in which they deposit their eggs,—thus forming a proper nidus for their offspring. The different proportions of the trunk, the mode of its insertion, the nature of the tibiæ, and the form of the abdomen, have given rise to the formation of several genera, such as Apoderus,[3] Attelabus,[4] Rhynchites,[5] and Apion.[6] The first is very strongly marked. The head is narrowed behind, or presents a neck-like prolongation, and unites with the thorax by means of a rotule. The muzzle is short, thick, enlarged at the end, a character common to the Attelabi properly so called; but in them, as well as in the other two genera, the head enters into the thorax up to the eyes, and the snout is elongated in the form of a proboscis. In Rhynchites the latter is somewhat widened at the end, and the abdomen is nearly square. In Apion, of which Mr Stevens enumerates ninety-one species as indigenous to Britain, the snout is not widened at the end, and frequently terminates in a point. The abdomen is large or inflated.[7] Here also are placed the genera Rhinotia and Eurhinus of Kirby,[8] and Tubicenus of Dejean (*Auletes*, Schœn.[9]).

Those in which the antennæ are filiform, or in which the terminal article alone forms the club,—in which the muzzle, often longer in the males than in the females, and differently terminated, is always borne in advance,—of which the proportions of the body are usually much lengthened, and in which the penultimate article of the tarsi is bilobed, form

Tribe 3d, Brentides, Lat.[10]

In the genus Brentus properly so called (Plate CCXXVI. fig. 15), the body is linear, and the antennæ filiform or slightly enlarged towards the extremity, and composed of eleven articulations. There is only one species of Brentus found in Europe, the *B. italicus*, which lives beneath the bark of trees, and generally, according to Savi the younger, of Pisa, in the same domicil with a certain species of ant. They are numerous in South America, and occur there also beneath the bark of trees. The genus Ulocerus, Schœn. resembles the preceding in general form, but the antennæ have only nine articulations, the last of which forms a little club. The last of this tribe is constituted by the genus Cylas, Lat. in which there are ten articulations to the antennæ, the last of which forms an oval club. The thorax seems divided into two knots, of which the posterior, forming the pedicle, is the smallest. The abdomen is oval.

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Sometimes the antennæ are distinctly geniculate (*Gonatoceri*), the first articulation being much longer than the following. These form the genus *Curculio* of Linn. or

Tribe 4th, Curculionites, Lat.

These seem naturally divisible into two lesser groups, according as the antennæ are inserted near the extremity of the proboscis (*Brevirostres* or *Brachyrhynchi*), or further back, either towards the centre, or near the base (*Longirostres*, or *Mecorhynchi*); "mais il n'est pas facile," says Latreille, "de bien determiner leurs limites, et plusieurs genres sont très-ambigues sous ce rapport."[11]

A. Brevirostres.

In the genus Brachycerus,[12] Fab. all the joints of the tarsi are entire, and without brush or pellet beneath. The antennæ are short, not much bent, and present externally only nine joints, the last of which forms the club. These insects are destitute of wings, and their body is very scabrous or uneven. They are characteristic of Southern Europe and of Africa, live on the ground, in sandy soils, and appear very early in the spring. The women of Ethiopia use one species as a sort of amulet, passing a string through its body, and hanging it around their necks.[13]

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[1] From ανθος, *flower*, and τρίβῶ, *I destroy*.

[2] From βρύκῶ, *I gnaw*.

[3] From απο, used to augment the sense of the word with which it is used, and δερε, *the neck*, which is much prolonged.

[4] From αττω, *to leap*, and λαβε, *seizure*. The name was originally applied by Aristotle to an orthopterous insect.

[5] From 'ρυγχος, *rostrum*.

[6] From ἄπιον, *a pear*, which the insects somewhat resemble in form.

[7] See Kirby in *Linn. Trans.* vol. ix.

[8] *Ibid.* vol. xii.

[9] *Curcul. Disp. Method.* 46.

[10] Gen. Brentus, Fab. Curculio, Linn.

[11] *Dict. Class. d'Hist. Nat.* t. xiv. p. 594.

[12] From βραχὺς, *short*, and κερας, *horn*.

[13] Caillaud, *Voyage au Fleuve Blanc*.

In the genus Curculio, Fab. almost the whole of the under parts of the tarsi are furnished with short stiff hairs forming pellets, and the penultimate article is deeply divided into two. The antennæ are composed of eleven articulations, or even of twelve, if we count the false one by which they are sometimes terminated. The last form the club. This splendid and extremely numerous genus, although greatly restricted by Fabricius, compared with its vast extent in the system of Linnæus, has been still more circumscribed by authors of the present day. An enormous accession of species having been discovered and described, these have been arranged by Germar, Schœnherr, Megerle, Dejean, and others, into a corresponding variety of generic groups, partly for the sake of convenience, and partly (though not entirely) because the nature of the subjects required such systematic modifications. Latreille's observations have led him to form these Curculiones into two principal divisions.

1*st*, Those in which the mentum, more or less widened superiorly, and more or less orbicular, occupies the entire breadth of the cavity of the mouth, and wholly or nearly conceals the maxillæ,—and in which the mandibles have no very sensible dentations, or merely exhibit a slight sinus underneath the point. The generic groups are as follows. In Cyclomus the tarsi (as in genus *Brachycerus*) are unprovided with brushes, and the penultimate articulation is entire, or very slightly notched, without distinct lobes. In this genus Latreille would comprise those named *Crytops*, *Deracanthus*, *Amycterus*, and *Cyclomus* of Schœnherr. The tarsi of all the others are furnished with brushes beneath, and the penultimate joint is deeply bilobate. Some are apterous. In Curculio properly so called (Plate CCXXVI. fig. 18), the lateral sulci of the proboscis are oblique and directed inferiorly. The anterior legs differ little in their proportions from the following ones. The genus, even thus restricted, comprises an immense number of groups, raised by Germar and Schœnherr to the rank of genera, "dont les caractères," says Latreille, "sont peu importants et souvent très-equivoques."[1] He thinks that at most only those should be detached of which the antennæ are proportionally longer. Among such as have short antennæ, the thorax longitudinal, and forming a truncated cone, the shoulders salient, and of which recent writers have formed the genera *Entimus*, *Chlorima*, and others, we find many noted South American species, of considerable size and exquisite beauty, and which, considered all in all, may be regarded as the most splendid examples of the coleopterous order. Such, for example, is *C. imperialis*, commonly called the diamond-beetle, which (may the scientific reader pardon the digression), inclosed in its little box, and covered by a microscope, has so often exhibited to the wondering gaze of youth hues more gorgeous than are ever seen in after days, when no glass, however potent, can dispel the mists which gather around whatever seemed the brightest and most beautiful of earthly things. The species just named is of a brilliant golden green, with two black longitudinal bands upon the thorax. There are several ranges of impressed or hollow spots upon the elytra, of a beautiful and sparkling green, with intervals of black, presenting the appearance of innumerable emeralds incased in gold and ebony. Such also is *C. regalis*, an insect still of great value, of which in former days a single specimen once sold in Paris for L.23 sterling. It is a good deal less than the diamond-beetle, of a bluish green, with extremely brilliant gold and copper bands upon the elytra. It is found in St Domingo and the island of Cuba. Many others, of almost equal beauty, will occur to the recollection of those who have inspected an extensive collection of foreign insects, and the specific names of *fastuosus*, *sumptuosus*, *nobilis*, and *splendens*, sufficiently attest the unfeigned admiration of the lovers of nature, of that bright attire which distinguishes these favoured creatures.[2] The genus Leptocerus[3] differs from the preceding in having the two anterior legs larger than the following, with the thighs thick, the tibiæ arcuated, and the tarsi often dilated and ciliated. The antennæ are usually long and slender. The thorax is almost globular or triangular, and is scarcely exceeded in width by the abdomen. These insects are very abundant in Brazil, and several analogous species are found in the Isles of France and Bourbon. Some inhabit Africa. Another genus, that of Phyllobius,[4] comprehends likewise winged species, but in which the grooves of the sides of the proboscis are straight, short, and consist only of a simple fossette. Several of these are extremely common in Britain. Along with the preceding, Latreille combines the genera *Macrorhynus*, *Myllocerus*, *Cyphicerus*, *Amblirhinus*, and *Phytoscapus*, of Schœnherr.

Those Brevirostres in which the penultimate joint of the tarsi is bilobate, but which are apterous, and always destitute of a scutellum, form other sub-genera, such as *Othiorhynchus*, *Omias*, *Pachyrhynchus*, *Psalidium*, *Thylacites*, *Syzygops*, and others.

2*d*, Those in which the mentum is narrowed, and, not occupying the whole of the cavity of the mouth, leaves the jaws exposed on either side. The mandibles, too, are evidently dentated. The club of the antennæ is frequently formed of the last five or six joints.

Some have scarcely more than two teeth to the mandibles. The labial palpi are distinct. The club of the antennæ, rather abrupt, does not commence, except from the eighth or ninth articulation, and is not elongated and fusiform. The body, though frequently oblong, is not of a uniform figure. Several are apterous, with the tarsi unfurnished with pellets, and their penultimate article feebly bilobed. Such is the genus Myniops of Schœnherr, with which Latreille combines *Rhytirrhinus* of that author. Several, likewise apterous, have, like most of the Rhynchophori, the under surface of the tarsi furnished with pellets, and the penultimate article deeply bilobed. They compose the genus Liparus, Lat. which comprises several genera of Schœnherr. Such as are winged form two additional genera,—that of Hypera, Germar, in which the tibiæ have either no hook at their extremity, or but a very small one, and that of Hylobius,[5] in which the hook at the internal extremity is very marked. Among the former, *H. tamarisci* (the type of the genus *Coniatus* of Schœnherr) rivals in its colours the most beautiful of the exotic species; among the latter we may name a well-known Scottish insect, *H. abietis*, Linn. (*Cur. pini* of Marsham[1]).

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[1] *Règne Animal*, t. v. p. 78.

[2] Even among our native Curculionidæ there are many species, though of small size, yet of exquisite beauty. The genera *Polydrusus* of Germar, and *Phyllobius* of Schœnherr, frequent the foliage of trees and of herbaceous plants. They excel most of the indigenous Coleoptera in brilliancy of colouring,—produced by a covering of minute scales, the body itself being dull and opake. These scales vary in shape, being often rounded and adpressed to the surface, at other times narrower, and having the appearance of hair. The prevailing colours are green or silvery-green, golden, and coppery, of various shades and different degrees of resplendency,—a considerable range of variation being observable even among individuals of the same species. Green, however, is by far the most common colour, and is no doubt intended to contribute to the preservation of the insect by assimilating it to the objects by which it is usually surrounded. (See *Entomologia Edinensis*, p. 253.)

[3] From λεπτος, *slender*, and κερας, *horn*.

[4] From φυλλον, *a leaf*, and βιος, *life*.

[5] From ὕλη, *wood*, and βιος, *life*.

Others have from three to four teeth upon the mandibles, the mentum abruptly narrowed near its upper extremity, and truncated, the palpi very small or imperceptible. The antennæ terminate gradually in an elongated fusiform club. The body has in most an analogous form. Olivier placed these insects in the genus Lixus, from which, in fact, they do not greatly differ. They compose the genus Cleonus, as constituted by Latreille.

B. Longirostres.

In this, the second group of the tribe Curculionites, the antennæ are inserted beyond the origin of the mandibles, and often near the centre of the proboscis, which is usually elongated. It comprises, with the exception of a few species, the genera *Lixus*, *Rhynchænus*, and *Calandra* of Fabricius. In the two former the antennæ are composed of at least ten articulations; they frequently consist of from eleven to twelve, of which at least the last three form the club.

The genus Lixus of Fab. (Plate CCXXVI. fig. 19) almost resembles *Cleonus* in the organs of manducation, the elongated fusiform club of the antennæ, the long and narrow form of the body, and the curvature of the tibiæ. *L. paraplecticus* (the species figured) is nearly linear. Its larva lives in the stem of *Phellandrium aquaticum*, and is alleged by Linnæus to occasion *paraplegia* among horses. The disease, as well as the plant, is called Staikra by the Swedes. The transformations of the insect are described by Degeer. Another species, *L. odontalgicus*, is a reputed cure for toothach.

The genus Rhynchænus of Fab. does not present an equal uniformity of character among its constituent parts, and has therefore been numerously subdivided. We shall mention a few of the modern groups.

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In some the legs are contiguous at the base, and there is no sternal groove for the reception of the proboscis. Of these a certain number never leap; their antennæ are composed of eleven or twelve joints, and their body is furnished with wings. Such are the genera Tamnophilus,[2] Bagous (small insects found in marshes), Brachypus,[3] Balaninus[4] (remarkable for the great length of the proboscis), Rhynchænus properly so called, and Sybines. Along with these may be placed Myorhinus of Schœnherr, and other genera, distinguished from the preceding by being apterous. In the genus Cionus the antennæ consist of from nine to ten joints. The body is usually very short, and almost globular. The ensuing differ from those above named in having very thick posterior thighs, which give the faculty of leaping. Those in which the antennæ are inserted on the proboscis form the genus Orchestes[5] of Illiger (Plate CCXXVI. fig. 20); those in which they originate between the eyes, that of Ramphus[6] of Clairville.

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In other Fabrician Rhynchæni the legs are remote at the base, and the sternum frequently exhibits a more or less extended cavity for the reception of the muzzle, and even sometimes for that of the antennæ. Those in which that sternal groove does not exist are formed by Latreille into two sub-genera, Amerhinus and Baridius. Those in which it does exist have been formed by Schœnherr into a great many genera, reduced to the following by Latreille, viz. Camptorhynchus, Centrinus, Zygops, Ceutorhynchus, Hydaticus, Orobitis, Cryptorhynchus, and Tylode.[7]

The last of the Longirostres have generally nine articles at most to the antennæ, of which only the last or the last two form the club, which is characterized by a coriaceous epidermis and spongy extremity. These insects live, at least in their larva state, on grain and ligneous substances. They form the great genus *Calandra*, now subdivided into the six following smaller groups.

The first two are apterous, the penultimate joint of the tarsi is bilobed, the antennæ are geniculate and inserted at a short distance from the middle of the trunk. In the first, genus Anchonus of Schœnherr, the antennæ exhibit nine articulations anterior to the short ovoid club, which is formed by the tenth, and perhaps by two others intimately united with it. In the second, Orthochætes of Germar,[8] it is the eighth joint which seems to form the club, although it is probably also of a compound structure. The four following are provided with wings. In the first three the tarsi, in accordance with the almost universal and implied character of the great *tetramerous* section of which they form a part, are all composed of four articulations, of which the penultimate is bilobed. In Rhina, Lat. (*Lixus*, Fab.), the antennæ are strongly geniculate, and inserted near the middle of a straight projecting proboscis,—their eighth joint forming a greatly elongated and almost cylindrical club. The anterior legs are longer than the others, at least in the males. Of this genus we may mention as an example a well-known and singular-looking insect, found in Cayenne and Brazil, called *R. barbirostris*, on account of a thick yellowish-brown beard which envelopes the proboscis of the male, and gives it somewhat the appearance of a bottle-brush. The female wants this kind of garniture on her snout, and she was consequently mistaken by Illiger for a separate species, and named *R. verrirostris*. In the genus Calandra properly so called, the antennæ, likewise strongly geniculate, are inserted near the base of the proboscis,—the eighth joint forming an ovoid or triangular club. The insects of this

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[1] It frequents the Scotch fir, and is common in the Edinburgh district, as well as throughout Scotland. It seems to occur pretty frequently over our southern borders, is more sparingly distributed in Cumberland and the adjoining counties, and, becoming gradually scarcer as we advance, is regarded as a rare insect in the southern parts of England. The imperfect description of this species given by Linnæus, who appears, in some of his works, to confound it with another insect, has rendered it rather difficult to identify his *Cur. Abietis*, and its synonyms have consequently become perplexed. From an inaccurately named specimen in the Linnæan cabinet, Marsham was led to believe that it was the *Cur. pini* of that illustrious observer, and he accordingly described it under that name in his *Entomologia Britannica*. Neither Paykul nor Fabricius appear to have formed accurate views of its characters,—the latter, in his *Species Insectorum*, regarding it as a sexual variety of an insect which in fact belongs to a different genus. The larva inhabits the wood of the Scotch fir, often proving very destructive to young plantations of that tree. The manners of the perfect insect are well described by Linnæus in his peculiar style: "Tarde incedit, arcte apprehendit, tenaciter adhæret, ore frustra cutem mordere tentat captivus."

[2] From ταμνω, or τέμνω, *to cut asunder*, and φίλος, *a lover*.

[3] From βϱαχυς, *short*, and πους, *foot*.

[4] From βαλανινος, *produced from an acorn*.

[5] From ὀϱχηστής, *a leaper*.

[6] From ϱαμφος, *the beak of a bird*.

[7] For their characters, see *Règne Animal*, t. v. p. 86–7.

[8] *Insectorum Species Novæ*, p. 302.

genus are but too well known for their destructive attacks upon grain, and are included with many others under the vague name of *weevil.* The most noted and injurious species *C. granaria* (*Cur. granarius*, Linn.), is fortunately rare in Scotland, and probably in most other northern countries. But in France and other continental territories it is extremely injurious. This little creature measures about a couple of lines in length, and is generally of a pitchy red, smooth, the thorax deeply punctured. The elytra are rather narrower than the base of the thorax, and do not cover the extremity of the abdomen. They are marked with deep striæ, punctured in the bottom. The legs are ferruginous. It is not in the perfect state that this destroyer commits its ravages. The season for the deposition of the eggs, and the periods of transformation, vary to a certain extent with the temperature of particular seasons; but generally in the south of France, as we are informed by M. Audouin, the female commences her maternal labours about the month of April, and continues them till the autumn. She first buries herself in a heap of grain, to the depth of some inches, and then commences to pierce their envelope, probably by means of a little dart concealed beneath the lower portion of the proboscis. The envelope is then raised, and a small hole bored, either in an oblique direction, or parallel with the surface of the grain. A single hole is made in each grain, and a single egg is laid in each hole, after which the opening is closed by a glutinous matter, so nearly resembling the colour of the grain, that it is extremely difficult to discover which is in a sound state, or which contains the germ of an insidious foe. The injured grains may, however, be detected by their floating when immersed in water, as well as by their feeling lighter when fingered by a practised hand. The egg thus laid is soon hatched, and gives birth to a very minute, white, soft, elongated worm, composed of nine segments, with a rounded corneous head, furnished with two strong mandibles, by means of which it daily enlarges its dwelling, fills its own stomach, and empties the purse of the farmer or grain-merchant. Having attained the term of its increase, it is transformed into a nymph, remains in that state for eight or ten days, and is transformed into a perfect insect, which, piercing the envelope of the grain, ere long produces in its turn a numerous progeny. The influence of temperature, so general on insect life, is effective on this noted *Charanson de blé;* but from forty to forty-five days may be stated as an average term between the union of the sexes and the reproduction of the perfect insect. When the old and unphilosophical belief prevailed of the spontaneous generation of the lower tribes of animal life, it was thought sufficient to say that these weevils were "engendered in the grain by humidity." At an after period it was thought by some who called themselves "observers"—(men of the same class with those who settle all natural phenomena by a paragraph in a newspaper, which they sign "Scrutator"),—that the perfect insect laid her eggs in the green ear, from whence, when the fields were ripe for harvest, they were transported to the stores of the granary. The accurate and inimitable Leeuwenhoeck (*Continuatio Epistolarum*, p. 56) dispelled these errors, and taught us the truth of nature, of which he was ever so great an interpreter. As each larva consumes only a single grain, we may form some idea of their power of increase, from the vast quantity sometimes destroyed. According to the calculation of Degeer, a single pair will produce (among themselves and their descendants), in the course of a season, *twenty-three thousand six hundred* individuals; so that, we may add, a few hundred weevils flying through the grating of a granary, and settling among its treasured heaps, might in the course of four or five months devour or destroy between *one and two hundred millions* of grains. Various modes have been suggested by economists and men of science to stay the progress of these destroyers. We are not sure that any of them have been found very efficacious. The most approved is the following: When the principal body of grain is suspected, let a small heap be placed apart in a corner, and the rest repeatedly stirred about and disturbed. The weevils, which love repose and a quiet life, will leave their usual domicils, and seek about for more peaceful dwellings. An instinct, which the foresight of man in this instance renders unavailing, induces them to settle on the smaller heap, and the shoveling of the main body being continued for some days, a vast number may be thus got quit of. Boiling water is then thrown upon the congregated insects, which have sought refuge in what they deemed a place of safety. As this process destroys only the perfect insects, and not the eggs or larva, neither of which care about being stirred up with any pole, however long, it must be employed during the earliest heats of spring, and before the laying of the eggs. It is said to succeed best when (whatever the principal store consists of) the decoy heap is formed of barley, which, it seems, is a favourite food of weevils. Reduction of temperature by ventilation has also been recommended, as tending to diminish their productive powers; and M. Clement thinks that dryness produced by lime may prove useful, by its tendency to destroy the eggs.[1] Of the larger kinds of Calandra we may mention *C. palmarum*, an insect known to all who have looked into collections of foreign Coleoptera, among which it is extremely common. It is a large species, measuring about an inch and a half in length. It occurs in South America. The larva (figured by Mad. Merian[2]) is named *ver palmiste* by the colonists. It lives in the heart of palm trees, and undergoes its transformations in a cocoon formed of the fibres of those lofty and plume-supporting plants.[3] It is fried and eaten as a great delicacy, both by Indians and Creoles. "C'est probablement," says M. Audouin, "quoi qu'en ait dit Linné, cette même larve, et non celle du Cossus, dont les Romains étaient si friands, et qu'ils nourrissaient avec de la farine." We cannot well see how this could be, unless the new world was known to the Romans, or Italy to the palmist worm. We believe, however, that the Cossus of the ancients was indeed the larva of a beetle (probably of one of the long-horned kinds), and not of a lepidopterous nocturnal insect, or *Cossus ligniperda*, commonly so called.

Our two remaining genera are Cossonus of Clairville and Dryopthorus of Schœnherr (*Bulbifer*, Dejean). In the former the antennæ, scarcely longer than the head and muzzle, have eight joints anterior to the club. They are thick, and inserted towards the middle of the muzzle. In the latter the antennæ have only six joints, of which the last forms the club. In regard to the tarsi the genus presents an anomalous character, and one which, if strictly applied to the definition of the section, would exclude it from the tetramerous families. They present five articulations, none of which are bilobed.

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[1] See *Dict. Class. d'Hist. Nat.* t. iii. p. 28; and *Journal de Physique*, t. lxxxix. p. 358.

[2] *Insectes de Surinam*, pl. 48.

[3] The palm which this insect most affects seems to be one of small size. According to Madame Merian, it grows to the height of a man, and is cut off when it begins to be tender, is cooked like a cauliflower, and tastes better than an artichoke. In its centre live innumerable quantities of larvæ, which at first are as small as a maggot in a nut, but afterwards grow to a very large size, and feed on the marrow of the tree. They are laid on the coals to roast, and are regarded as a "most pleasant food."

FAMILY II.—XYLOPHAGI.[1]

These exhibit a head formed in the ordinary way, without any obvious muzzle, or trunk-like projection. The antennæ are thicker at their extremity, or perfoliated from their base, always short, and consisting in a great number of less than eleven articulations. The joints of the tarsi are usually entire, but with the penultimate enlarged and heart-shaped in some, in which case the antennæ always terminate in a club, either solid and ovoid, or trifoliate, with the palpi small and conical. These insects mostly live and feed in wood, from which habit they derive their family name; and their larvæ are often destructive to timber, in consequence of the ramified perforations which they form in all directions beneath the bark. They frequently so abound in forests of fir and pine, as to render in a few years an immense number of trees entirely useless for all the purposes of human art. Others are extremely injurious abroad to the olive plantations, while several feed on mushrooms. Latreille divides them into three sections.

1*st*, Those of which the antennæ have at most ten joints, and are sometimes terminated by a strong club (generally solid, in others composed of three elongated leaves), sometimes form from their base a cylindrical and perfoliated club; the palpi conical. The anterior tibiæ of the greater number are dentated, and armed with a strong hook; and the tarsi, of which the penultimate article is frequently bilobed or heart-shaped, are capable of being bent or folded on them.

Some have very small palpi, the body convex and rounded above, or almost ovoid, with the head globular, sunk into the thorax, and the antennæ terminated by a solid or a tri-lamellar club, preceded by at least five joints. These Xylophagi compose the old genus SCOLYTUS[2] of Geoffroy, which Linnæus did not distinguish from *Dermestes*. They now form the genera HYLURGUS, Lat., HYLESINUS,[3] Fab., SCOLYTUS proper (Plate CCXXVI. fig. 22) of Lat., CAMPTOCERUS, Dejean, PLOIOTRIBUS and TOMICUS, Lat., and PLATYPUS, Herbst.[4] Of many of these each female deposits numerous eggs, and 80,000 wood-eating larvæ have been calculated to inhabit a single tree.

Others have the palpi large and obvious, and of unequal length. Their body is depressed, narrowed in front; their antennæ are sometimes apparently only bi-articulate, with the last joint very large, flattened, almost triangular or ovoid, and sometimes consist of ten joints, entirely perfoliate. The labrum is large. The elytra are truncated, and the tarsi short, with all the articles entire. These insects are all exotic, and compose the genus PAUSSUS of Linn.[5] It has been greatly increased in recent times, and is now divided into several genera.[6]

2*d*, Those of which the antennæ consist of only ten articulations, and of which the palpi, at least the maxillary ones, do not taper gradually to a point, but are of equal thickness throughout, or dilated at the extremity. The joints of the tarsi are always entire. The constituent groups form two principal genera, according to the mode in which the antennæ are terminated. Thus, in BOSTRICHUS the three terminal joints form a perfoliated club. These insects however form four lesser genera, viz. BOSTRICHUS proper (e. g. *Dermestes capucinus*, Linn.) Plate CCXXVI. fig. 24, PSOA, Fab., CIS, Lat., and NEMOSOMA, Desmarets. The second principal genus, called MONOTOMA, is distinguished by the solid and button-like form of the tenth articulation of the antennæ, and is likewise further divisible into four minor genera,—SYNCHITA, Helw., CERYLON, Lat., RHYZOPHAGUS, Herbst, and MONOTOMA proper.

3*d*, The Xylophagi of the third division have eleven very distinct articles to the antennæ; the palpi vary, being filiform or thickened at the extremity in some, more slender at their termination in others. All the joints of the tarsi are entire. Among the LYCTI the club of the antennæ consists but of two joints. They form the genera LYCTUS[7] proper, DIODESMA, Meg., BITOMA, Herbst. Among others the last three or four joints of the antennæ form the club, or the last alone is larger than the preceding ones. In the MYCETOPHAGI, Fab. the mandibles are covered, or project but little. In Latreille's arrangement they form the following seven genera:—COLYDIUM and MYCETOPHAGUS (proper),[8] Fab., TRIPHYLLUS, Meg., MERYX, Lat., DASYCERUS,[9] Brongniart (Plate CCXXVI. figs. 26 and 28),[10] SYLVANUS, Lat., and LATRIDIUS, Herbst. The species of the last-named genus are exceedingly minute, none of them exceeding a line and a half in length, and several being scarcely half that size. They occur in houses, vaults, cellars, &c. and are not unfrequently found beneath the bark of trees. From their habits they are called lurking beetles (Lauerkäfer) by the Germans. Their generic name (from *Lateo?*) has probably the same signification. The larvæ are somewhat egg-shaped and elongate, consisting of twelve segments of a dirty white colour, the antennæ and legs clear as water, with a black line along the back, and a tuft of hairs on the sides of each segment. They live for a longer or shorter period in this condition, according to the state of the temperature and supply of food; the usual time is from four to six weeks. They then change into nymphs of a transparent white, with brownish-yellow eyes, from which, in about fourteen days, emerge the perfect insects.[1] We have about a dozen species in Britain.[2] In the TROGOSITÆ,[3] Olivier and Fab. (*Platycerus*, Geoffroy), the mandibles are entirely exposed, salient and robust. The body is generally elongated, narrow, and depressed. In some of these the antennæ are shorter than the thorax, or at most of equal length, and terminate in a compressed club, a little toothed or serrated, and formed by the three or four last articulations. The ligula is entire. In TROGOSITA proper the mandibles are shorter than the head, and crossed. The maxillæ have but a single lobe. *T. mauritanica* (*Tenebrio mauritanicus*, Linn.), about four lines in length, blackish above, light brown beneath, with striate elytra, occurs in nuts, bread, and beneath the bark of trees. The larva, known in Provence under the name *Cadelle*, attacks grain. Here follow the genera PROSTOMIS of Lat. and Passandra of Dalman.

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[1] From ξυλὸν, *wood*, and φαγος, *eating*.

[2] From σκολίοτης, *tortuosity*.

[3] From ὑλη, *wood*, and σινω, *I injure*.

[4] For their characters see *Règne Animal*, t. v. p. 91–2, and the works there referred to.

[5] The genus *Paussus* did not exist in the twelfth edition of the *Systema Naturæ*, but was published by Linnæus in a separate dissertation in 1775. Only a single species appears to have been known at that period (Mr Westwood now describes above twenty), and another was added in 1796 by Dr Adam Afzelius, then residing at Sierra Leon (*Linn. Trans.* vol. iv.). The etymology of the name is supposed by Afzelius to be from the Greek παυσις, signifying a pause, cessation, or rest; for Linnæus, now old, infirm, and sinking under the weight of age and labour, saw no probability of continuing any longer his career of glory. "He might therefore," adds Dr Shaw, "be supposed to say, 'Hic meta laborum,' as it proved in reality, at least in regard to insects—Pausus being the last he ever described." (*Gen. Zoology*, vol. vi. p. 43.) It was literally, in the language of Young, "An awful *pause*, prophetic of his end."

[6] See an elaborate and learned Essay *On the Paussidæ, a family of Coleopterous Insects*, by Mr J. O. Westwood, *Linn. Trans.* vol. xvi. p. 607.

[7] From λυγτος, *smooth or polished*.

[8] From μυκετος, *moss*, and φαγος, *eating*.

[9] From δασυς, *hairy*, and κερας, *horn*.

[10] We have figured the type of the genus, *D. sulcatus*, on the plate above referred to. This singular little insect was discovered by M. Alex. Brongniart on a fungus in the forest of Montmorency. It is extremely small, and it is difficult to count the articulations of the tarsi, even with the aid of a good microscope. These parts consist, however, of only three articulations (see fig. 31), which would remove the genus from the tetramerous section, were it not allied to the above genera by other natural characters. The first two joints of the antennæ (see fig. 21) are globular, the following ones very small, capillary and pilose, and the last three or four also pilose and globular.

FAMILY III.—PLATYSOMA.[4]

This group of tetramerous Coleoptera approaches the preceding so far as relates to the internal structure, the tarsi, and the habits; but the antennæ are of equal thickness throughout, or more slender towards their termination. The mandibles are always projecting; the ligula is bifid or emarginate; the palpi are short, and the body depressed and lengthened, with the thorax nearly square. These insects are found beneath the bark of trees, and are reduced by Latreille to the CUCUJI of Fabricius, which he distinguishes as CUCUJUS proper (Plate CCXXVI. fig. 21), DENDROPHAGUS, Gyll. and ULEIOTA, Lat.

FAMILY IV.—LONGICORNES.

The insects of this family, which in the system of Linnæus formed the genera *Cerambyx*, *Leptura*, and *Necydalis*, have the under surface of the first three articles of the tarsi garnished with brushes, the second and third being heart-shaped, the fourth deeply bilobed, with a little swelling or nodule resembling an articulation at its base.[5] The ligula, borne upon a short and transverse mentum, is generally membranous, heart-shaped, emarginate or bifid,—in others corneous, and forming the segment of a very short and transverse circle. The antennæ are filiform or setaceous, generally at least as long as the body, sometimes simple in both sexes, sometimes serrated, pectinated or flabelliform, in the males. The eyes of a great number are reniform, and surround the antennæ at their base. The thorax is in the form of a trapezium, narrowed anteriorly in such as have the eyes rounded, entire, or slightly emarginate; in which case also the legs are long and slender, and the tarsi lengthened. M. Leon Dufour has remarked that the Longicornes, in regard both to the alimentary tube and the disposition of the hepatic vessels, generally resemble the Melasoma, and, contrary to the opinion of M. Marcel de Serres, he denies the existence of a gizzard. The alimentary canal, usually beset with papillæ, is preceded by a crop, which is smaller and less distinctly marked in Lamia and Leptura, the concluding genera.

The larvæ of almost all the Longicornes live in the interior or beneath the bark of trees. They are either apodal, or provided with very inconspicuous legs. Their body is soft, whitish, largest anteriorly, with a squamous head, furnished with strong mandibles, but without any other projecting parts. They are extremely destructive to the larger forest trees, piercing them to a considerable depth in all directions. A certain number gnaw the roots of plants. The abdomen of the female, in the perfect state, is terminated by a tubular and corneous oviduct. Several species produce a sharpish sound by rubbing a portion of the thorax against the pedicle which attaches the base of the abdomen. Lister calls this sound *querulous*, while Dumeril compares it to the braying of an ass. It is on account of this peculiarity that *Prionus coriarius* is known in Germany by the name of the *Fiddler*. Of this numerous and graceful family some are nocturnal, and frequent old woods and the trunks of ancient trees; others occur on flowers and among flowering shrubs and hedges, and are richly gilded and adorned with various colours;—while all are remarkable for their elongated bodies, their lengthened limbs, and their long and delicately formed antennæ. Several of the species are among the very largest of the coleopterous tribes. The deficiency of wood in our northern quarter of the island is a circumstance unfavourable to the frequent occurrence among us of these lovers of "forest scenery." Even of the English species commonly so called, a few of the finest are probably not original inhabitants of Britain, but have rather been accidentally imported in the larva state in foreign timber, and have afterwards, when excluded in the perfect form, contrived to wing their way, and colonize among our native woods. Their characteristic position is in countries adjoining the equator (especially in South America), and they seem to diminish both in size and number in proportion to their distance from the torrid zone. Britain in general, and more especially Scotland, are considerably to the north of the limit where these insects cease to be common; and in other respects our island presents few local peculiarities at all adapted to their increase. Yet the indefatigable Mr Stephens enumerates about one hundred indigenous species of Longicornes, including, however, certain genera, such as *Trogosita* and *Cucujus*, which Latreille and others do not admit among the long-horned tribes.

According to the system by which we are at present guided, the Longicornes are divisible in the first place into two sections.

A.

Eyes either emarginate or crescent-shaped, or elongated and narrow. Head sunk into the thorax as far as the eyes, without any neck-like restriction,—and vertical in many.

a.

In some the articulation of the palpi is in certain cases nearly in the form of a cone, or reversed triangle; in others nearly cylindrical, and truncated at the extremity. The terminal lobe of the maxillæ is straight (not curved upon the inner one at its extremity); the head generally projected or simply inclined, and when, by a rare exception (as in *Dorcacerus*), its position is vertical, its breadth then nearly equals that of the body, and the antennæ are distant at their base, and spiny. The thorax, often unequal or square, is rarely cylindrical. They are subdivisible into two lesser tribes as follows:

TRIBE 1ST, PRIONII.

Distinguished by the labrum being absent, or extremely small and indistinct; the mandibles strong, or even very

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[1] For a more detailed account, see Germar's *Magazin der Entomologie*, vol. ii.

[2] Stephens' *Nomenclature*, col. 32.

[3] From τρωγω̃, *I gnaw*, and σιτος, *corn*.

[4] From πλατος, *breadth* or *flatness*, and σω̃μα, *body*.

[5] Latreille remarks, that in regard to the above character, the *Parandræ* perfectly resemble the Longicornes; and that hence, if we consider the little nodule as a genuine joint, both our present family and that which follows might be regarded as pertaining to the great pentamerous section.

Coleoptera Tetramera.

large among the males, and the internal lobe of the maxillæ small or imperceptible. The antennæ are inserted near the base of the mandibles, or of the emargination of the eyes, but are not surrounded by them at their origin. The thorax is most frequently trapezoidal or square, and notched or dentated on the sides.

In the genus Parandra of Lat. the antennæ are simple, almost granose, compressed, of the same size throughout, and at most as long as the thorax; and the ligula is corneous, in the form of a short segment of a circle, transverse, and without emargination. The body is depressed, and parallelopiped, with the thorax square, rounded at the posterior angles, and without any teeth or spines. These tribes are peculiar to America. In Spondylis, Fab. (*Attelabus*, Linn.) the antennæ and maxillary lobes resemble those of the preceding; but the ligula, as in all the ensuing Longicornes, is membranous. The thorax is almost globular, without margins, and unarmed with teeth or spines. The species, which are few in number, inhabit Europe, and their larvæ occur in trees of the pine tribe. In the genus Prionus[1] of authors (Plate CCXXVI. fig. 33), the antennæ are longer than the head and thorax,—serrated or pectinated in some,—simple, attenuated towards the extremity, and with elongated articulations, in others. The terminal lobe of the maxillæ is at least as long as the first two articulations of the palpi. The body is generally depressed, with the body square or trapezoidal, and either toothed or spiny, or presenting a lateral projecting angle. These insects are said to take wing only during the night or evening. When reposing they occur on trees. Some exotic species are remarkable for their great size, and their projecting mandibles. " C'est dans ce genre," observes M. Guerin, " qui sont les plus grands Coléoptères connus, puisque certaines espèces Américaines atteignent plus de six pouces de longueur."[2] The larvæ of *P. cervicornis*, which dwell in the wood of the Gossampinus, are used as articles of food. We have only four or five species of this genus in Europe, of which *P. coriarius* is the sole British species. It is one of our largest insects, measuring about fifteen lines in length. The larva lives in the decaying trunks of oaks and birch trees. It undergoes its metamorphosis under ground. *P. giganteus* is above half a foot in length. It fortunately inhabits Cayenne.

Tribe 2d, Cerambycini.

In these the labrum is very apparent, and extends across the entire width of the anterior extremity of the head; the two maxillary lobes are very distinct and projecting; the mandibles are of ordinary size, and similar, or differing but slightly, in the two sexes. The eyes are always emarginate, and surround, at least in part, the base of the antennæ, which are usually the length of, or longer than, the body. The thighs, at least the anterior four, are commonly in the form of an ovoid club, restricted to a pedicle at the base.

Latreille commences with such as have the last articulation of the palpi always obviously thicker than the preceding ones, and in the form of a triangle or reversed cone. The head is not sensibly narrowed, and prolonged anteriorly in the form of a muzzle; the thorax is not widened from before backwards, and does not present the figure of a trapezium or of a truncated cone; the elytra are neither very short and squamiform, nor abruptly narrowed a little beyond their base, and subulate at the extremity. These may be termed the *regular Cerambycini*, in contradistinction to those of a more anomalous nature, by which we shall be afterwards conducted to another tribe. They compose the genera *Cerambyx, Clytus*, and *Callidium* of Fabricius, and a portion of his *Stenocori;* and consist of the great Linnæan genus *Cerambyx*, with the addition of some *Lepturæ* of the Swedish naturalist. Certain modern entomologists have greatly augmented the number of generic groups; but Latreille regards the characters assigned for their distinction as by no means sufficiently precise. We shall here notice the principal genera, as admitted in the *Règne Animal.*

A considerable amount of species, all from South America, have the body proportionally shorter and broader than those that follow, and are remarkable for the extent of the thorax, which nearly equals half the length of the abdomen. The anterior legs at least are distant at their base. The scutellum is large in several species. The antennæ are often pectinated, serrated, or spiny. Those of this division, of which the thorax, nearly semi-orbicular and always very large, is smooth or merely chagrined, with a single tooth on either side at the posterior angles,—of which the posterior extremity of the præsternum is plane, truncated, without emargination, or emarginate, and placed upon the mesosternum,—of which the scutellum is always very large, and the legs distant at their origin—form the two following genera:—Lissonotus of Dalman (Plate CCXXVI. fig. 35), in which the antennæ are strongly compressed, serrated or semi-pectinated, and long, with the posterior extremity of the præsternum unemarginate:—Megaderus of Dejean, in which the antennæ are simple and shorter than the body, and the posterior extremity of the præsternum emarginate, and receiving the opposing end of the mesosternum. Those, again, of which the thorax is extremely unequal, tubercular, or with many dentations, and the præsternum carinated or terminated posteriorly in a point, form the following four genera,—Dorcacerus,[3] Dejean, Trachyderes, Dalman (Plate CCXXVI. fig. 37), Lophonocerus,[4] Lat. (Plate CCXXVII. fig. 1), and Ctenodes, Olivier and Klug.[5]

In other groups of species, the thorax, sometimes square or cylindrical, sometimes orbicular or nearly globular, is very much shorter than the elytra, at least in those in which it is extended in breadth, and the præsternum presents neither a carina nor pointed prolongation at its posterior extremity. The scutellum is always small, and the legs are approximate at their origin. Several, remarkable for their beautiful metallic colouring, and the agreeable odour which they exhale, exhibit rather an anomalous character in regard to the relative proportions of the palpi,—the maxillary being smaller than the labial, and even shorter than the terminal lobe of the maxillæ, which frequently projects. The body is depressed, with the anterior of the head narrow and pointed. The hinder tibiæ are often much compressed. They form the genus Callichroma[6] of Latreille (*Cerambyx*, Fab. Dejean). A species well known in England, but which we have not traced farther north than Westmoreland, and remarkable for its strong odour of roses, is the *Cal. moschata* (*Cer. moschatus* of Linn. and of the English naturalists). It measures about an inch in length. South America, and the equatorial regions of the ancient continent, furnish several species. Other Longicornes of this division, but in which the maxillary palpi are as usual at least as long as the labial, and surpass the extremity of the maxillæ, are distinguished from such as follow, by the antennæ, particularly of the males, having twelve distinct articulations instead of eleven. These parts are always long, setaceous, and not unfrequently spiny or bearded. The thorax is toothed or spiny on the sides. These are united by Latreille under the genus ACANTHOPTERA[1] (*Callichroma*, *Purpuricenus*, *Stenocorus*, Dej. Dalm.). Certain species with the thorax nearly square or cylindrical, and the elytra generally terminated by one or two spines, enter into the genus *Stenochorus* of Dalman. Others, more characteristic of the western countries of the ancient continent, form the genus *Purpuricenus* of Ziegler and Dejean. An elegant insect of a pale ashy blue, with three black spots on each elytron, and several joints of the antennæ furnished with tufts of hair, is the *Acanth. alpinus* of Lat. recently removed from the genus Callichroma. It smells strongly of musk. We took it among the Alps of Switzerland, and have since received a specimen captured in a timber-yard in Paris.

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[1] From *πϱιον, a saw.*

[2] *Dict. Class. d'Hist. Nat.* t. xiv. p. 282.

[3] From δοϱϰας, *a goat* or *antelope*, and ϰεϱας, *horn.*

[4] From λοφος, *a tuft*, and ϰεϱας, *horn.*

[5] For the characters by which these genera are distinguished from each other, see *Règne Animal*, t. v. pp. 111–12.

[6] From ϰαλος, *beautiful*, and χϱωμα, *colour.*

The following Cerambycini have only eleven articulations to the antennæ.

In some these organs, at least in the males, are long and setaceous; the terminal article of the palpi is in the form of a reversed cone; the thorax is either square or a little dilated in the middle, or oblong and almost cylindrical; it is often rugose or tuberculated laterally. They compose the genus CERAMBYX properly so called[2] (Plate CCXXVII. fig. 2). Of these, certain species form the genus *Hamaticerus* of recent writers. Such is *C. heros* of Fab. an inhabitant of the temperate and warmer regions of Europe. It is one of the largest Coleoptera of the European continent. The larva forms deep excavations in the wood of the oak, and has been deemed by some the *Cossus* of the ancients. As it is not now the custom to eat grubs, that disputed question still remains obscure. Latreille places in this niche of the entomological system various Callichromæ (so called) of Dejean, with a smooth or but slightly unequal thorax. Most of them belong to South America. They are in general beautifully ornamented by the hand of nature, though their size is small. Some are singularly distinguished by one or more little globular tufts of hair upon the antennæ, and even the hind legs of certain species are similarly adorned. The thighs of these insects (some of which were arranged by Fabricius and Olivier among the *Saperdæ*) resemble a club-like mass, supported upon a more lengthened pedicle. The antennæ consist of long and slender articulations. In the genus GNOMA of Dejean the thorax is long and cylindrical. The palpi are almost filiform, and the inner side of the mandibles presents a tooth. The species occur in America.

In the extensive genus CALLIDIUM[3] of Olivier, the antennæ are in general scarcely longer than the body, and are rather filiform than setaceous. The thorax, always unarmed, is sometimes nearly globular or orbicular, sometimes more narrow, nearly cylindrical, and simply dilated and rounded in the centre. The palpi, always very short, are terminated by an article rather thicker and broader than the preceding ones, and in the form of a reversed triangle. These insects now form the genera CERTALLUM of Megerle and Dejean, CLITUS of Fabricius, and CALLIDIUM properly so called. Of the second and last we have several British species.

Latreille concludes our present tribe of insects with certain species, which, in regard to the palpi, the form of the head, thorax, and elytra, and their general proportions, offer some remarkable and anomalous characters. He commences with such as present a thorax analogous to that of the preceding, especially the genus *Certallum*. It is as broad as the head, and as the base of the elytra, or scarcely narrower, and is either almost cylindrical, or rounded, or nearly orbicular; in both cases wider near the middle. The terminal articulation of the palpi is sometimes attenuated near the end, and terminated in a point, sometimes thicker and truncated, and obconical. All the thighs are clubbed, and supported by an abrupt, slender, and lengthened pedicle. The elytra of the greater number are either very short, or abruptly narrowed at a little distance from their base, and then subulate.

In the genera OBRIUM of Megerle, and RHINOTRAGUS of Dalman, the elytra do not exhibit those peculiar forms; but in Necydalis, Linn. those parts are either very short and scale-like, or prolonged, as usual, as far as the extremity of the abdomen, and abruptly contracted a little beyond their origin, then greatly narrowed, and terminated in a point. They do not resemble the ÆDEMERÆ, with which they were arranged by Fabricius, except in the form of the elytra. They are divisible into two minor groups. For example, those with subulate elytra form the genus STENOPTERUS[4] of Illiger (Plate CCXXVII. fig. 5), while such as have them short and squamiform continue to bear the name of NECYDALIS (ibid. fig. 3).

Certain insects, for the most part proper to the African islands, to New Holland, New Ireland, and New Zealand, present some ambiguous characters; and, according to Latreille, ought perhaps, in a natural order, to be placed between the Lamiariæ and the Lepturetæ. In the mean time, however, he concludes with them the tribe Cerambycini. The palpi are almost filiform, with the terminal articulation nearly cylindrical, slightly attenuated towards the base. The thorax is usually smooth, or but slightly uneven, without acute tubercles, is widened posteriorly, or presents the form of a trapezium or of a truncated cone. The abdomen is almost in the form of a reversed triangle in the greater number, and the elytra are truncated at the extremity. They form four genera, viz. DISTICHOCERA, Kirby, TMESISTERNUS, Lat., TRAGOCERUS, Dejean, and LEPTOCERA of the last-named author.

b.

In other Longicornes, forming

TRIBE 3D, LAMIARIÆ,

The head is vertical and the palpi filiform, or scarcely larger at their extremity, and terminated by an article more or less ovoid, and tapering to a point. The exterior lobe of the maxillæ is a little narrowed at the extremity, and curved upon the inner division. The antennæ are most frequently setaceous and simple, and the thorax, exclusive of the lateral tubercles or spines, is nearly of an equal width throughout. Some species are apterous,—a character not exhibited by any other division of the family.

Our present tribe, in the system of Latreille, is composed of the genera *Lamia* and *Saperda* of Fabricius, of some of the *Stenocori* of that author, of the *Colobotheæ* of Dejean, and of several of his *Cerambyces*.

The genus ACROCINUS of Illiger is constituted by an insect of a very striking and extraordinary aspect, the *Cerambyx longimanus* of Linn. The genus is distinguished

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[1] From ακανθα, *a spine*, and πτερον, *a wing*.

[2] From κερας, *horn*, and βους, *an ox*.

[3] From καλος, *beautiful*, and ιδεα, *form*.

[4] From στενος, *narrow*, and πτερον, *wing*.

Coleoptera Tetramera.

from all the Longicornes by the thorax being provided on each side with a moveable tubercle, terminated by a point or spine. The body is flattened, with the thorax transversal; the antennæ are long and slender; the anterior legs much longer than the others, especially in the males; and the elytra are truncated at the end, and terminated by two teeth, of which the exterior is the strongest. The singular species above named, of which the colours present an agreeable mixture of grey, red, and black, is known to the French colonists by the name of the *Harlequin* of Cayenne. It is a very large insect. The *Prionus accentifer* of Olivier pertains to the same genus.

All the other Lamiariæ are referable to the great genus Lamia (Plate CCXXVII. fig. 4), which, however, has been extensively subdivided in modern times. A great number of species, chiefly from South America, of which the legs are robust and the tarsi much dilated, fall under the genus Acanthocinus of Megerle and Dejean. Not more than three species are known in Europe. Of these we received *A. ædilis* (called the *Carpenter* in France), from a wood near Inverness; and Sir Thomas Dick Lauder informs us that he likewise took it in a forest of that northern county. Specimens from the neighbourhood of Kirkaldy are preserved in the collection of Sir Patrick Walker. The species is remarkable for the great extent of the antennæ, which in the males are four times the length of the body. It is characteristic of northern countries, and most of the British examples have occurred in Scotland. "Habitat frequens," says Linnæus, writing in reference to Sweden, "in linteribus et arborum truncis decorticatis, dum ex his domos struunt ruricolæ, hinc pueris nostris dicitur *Timberman* omnibus notissima species: vulgus hunc lædere religiose apud nos ducet."[1] Others of an analogous form, but of which the antennæ are garnished with hairs, compose the genus Pogonocherus[2] of the same authors. Britain produces four species, of which two occur in Scotland. Certain apterous kinds compose the genus Dorcadion[3] of Dalman. These insects are proper to Europe and the neighbouring countries of Asia. Their antennæ are generally shorter than the body, with their articulations in the form of a reversed cone, which gives them a knotted aspect. A species common on the continent of Europe (*Cer. fuliginator*, Linn.) is almost exclusively confined to calcareous soils.

Other Lamiariæ have the thorax cylindrical, and unfurnished with tubercles or spines. The body is always elongated,—in some almost linear. They compose the genus Saperda of Fab., which has been greatly subdivided. We have several British species, of which we shall here name only *S. carcharias*, an insect about an inch in length, covered with a yellowish ashy down, spotted with black, and the antennæ coloured alternately with black and grey. Its larva lives in the trunk of the poplar, and sometimes proves injurious to plantations of that tree.

B.

In this our second principal section of the Longicornes, forming

Tribe 4th, Lepturetæ,

The eyes are rounded, entire, or scarcely emarginate, and the antennæ are then inserted forwards, or at most at the anterior extremity of that feeble emargination. The head is always inclined, prolonged posteriorly behind the eyes in several, or abruptly narrowed into a neck-like form at its junction with the thorax. This last part is conical or trapezoidal, and narrowed anteriorly. The elytra become gradually narrower from the base. This tribe corresponds to the genus *Leptura* of Linnæus, with the exception of a few species which fall more naturally among the preceding tribes, and also of such as belong to the more modern genus *Donacia*. We shall here notice only a few of the genera which, as native to our own island, are the most likely to interest the British naturalist.

In the genus Rhagium (of which we have three indigenous species) (Plate CCXXVII. fig. 6), the antennæ are simple, and at most not more than half the length of the body. The terminal articulation of the palpi forms a triangular club. The head is large, almost square, with the eyes entire. The sides of the thorax are furnished with a conical or spinous tubercle. In the genus Toxotus[4] the antennæ are at least as long as the body, simple, with the first article much shorter than the head. The eyes are entire, or very slightly emarginate. The body is triangular, or forms a lengthened square, narrowed posteriorly. *T. meridianus* and *chrysogaster* are supposed to be synonymous,—in which case we have probably not more than two British species. In the genus Leptura[5] properly so called, the head is abruptly narrowed immediately behind the eyes, and the antennæ, inserted near the anterior extremity of their inner emargination, are distant at their base. The two usual eminences from which they spring are almost confounded in one plane. The thorax is almost always smooth, or without lateral tubercles. The majority of the genus occur in Europe, and Britain produces about a score. Few of them have yet occurred in Scotland, probably owing to our comparative deficiency in wood. We have met with only one species in the neighbourhood of Edinburgh, *L. ruficollis*.

FAMILY V.—EUPODA.

Some of the component parts of this family are nearly allied to the Longicornes or preceding tribes, while others so much resemble the Chrysomelæ as to have been arranged with the latter by Linnæus. The organs of manducation present the same range of affinities. Thus, among the Donaciæ, the ligula is membranous, bifid or bilobed, as among the Longicornes, and their maxillæ are very analogous to those of the latter; while among the concluding Eupoda the ligula is almost square or rounded, and analogous to that of the ensuing family, called Cyclica. At the same time the maxillary lobes are membranous, or but slightly coriaceous, whitish, or of a yellowish hue; the exterior expands towards the extremity, and has not the figure of a palpus,—a feature which allies our present family rather to that which we have left than to the one which follows. The body is more or less oblong, with the head and thorax narrower than the abdomen. The antennæ are filiform, or gradually enlarge towards the extremity, and are inserted before the eyes. These are in some entire, round, and projecting, in others slightly emarginate. The head is received posteriorly by the thorax, which is cylindrical, or in the form of a transverse square. The abdomen may be called large when compared with the other parts, and forms a lengthened square, or elongated triangle. The articulations of the tarsi, excepting the terminal one, are furnished beneath with little cushions, and the penultimate is bifid or bilobed. The posterior thighs are very large in many species,

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[1] *Fauna Suecica.*

[2] From πωγων, *beard*, and κεραs, *horn.*

[3] δορκαδιόν, *a small species of deer.*

[4] τοξοτης, *an archer?*

[5] Named from λεπτος, *slender*, and ὄυρα, *the tail*, in allusion to the attenuated form of the elytra.

Coleoptera Tetramera.

and it is from that character that the family derives its name. They are all winged insects, and occur on the stems and leaves of various plants, especially, so far at least as many of the European species are concerned, on the liliaceous tribes. The larvæ of the Donaciæ feed on the internal portion of the roots of aquatic plants. Those of other genera live exposed, but, after the manner of the Cassidæ, cover themselves with a case or scabbard formed of their own excrementitious matter. Latreille divides the family into two tribes.

TRIBE 1ST, SAGRIDES.

The mandibles terminate in a sharp point. The ligula is deeply emarginate or bilobed.

In some the palpi are filiform, the eyes emarginate, the posterior thighs very large and strong, and the tibiæ arcuated. We here place the genera MEGALOPUS,[1] Fab. and SAGRA properly so called (Plate CCXXVII. fig. 7). The former insects are proper to South America; the latter, although one occurs in Africa, are characteristic of China, and the great eastern islands, such as Java, the Celebes, and Ceylon. Some of the Sagræ are among the richest and most beautiful of the coleopterous tribes. There is something striking in their gigantic limbs, and their colours consist of burnished green and gold, mingled with violet and deep flame colour.

In others the palpi are enlarged at their extremity, the eyes entire, and the thighs of nearly equal dimensions. Such are the genera ORSODACNA of Lat. and PSAMMŒCUS, Boudier.[2]

TRIBE 2D, CRIOCERIDES.

The extremity of the mandibles is truncated, or presents two or three teeth. The ligula is entire, or but slightly emarginate. These insects correspond to the genus CRIOCERIS[3] of Geoffroy, which Latreille divides as follows.

In some the mandibles taper to a point, and present two or three teeth at the extremity. The palpi are filiform, the antennæ of ordinary thickness, almost granose in certain species, and chiefly composed in others of articulations in the form of a reversed cone, or perceptibly thicker towards their superior extremity.

In the genus DONACIA, Fab. (Plate CCXXVII. fig. 8), the posterior thighs are large and inflated. The antennæ are of equal size throughout, and composed of lengthened articulations. The eyes are entire, and the terminal joint of the tarsi is inclosed, for the greater part of its length, by the lobes of the preceding articulation. This interesting genus was confounded with *Leptura* by Linnæus and Degeer, and with *Stenochorus* by Geoffroy. It was established by Fabricius under its present name, from δοναξ, *a reed*, on account of the species of which it is composed being found on reeds and other aquatic plants, such as those of the genus Iris, Saggitaria, Nymphæa, &c. to which they cling with great tenacity, and on the roots of which the larvæ are supposed to feed. In the form of their bodies and antennæ they show an alliance to the Cerambycidæ, but their habits, and the structure of the cibarian organs, ally them still more closely to *Crioceris* and *Galeruca*. They are frequently bronzed or gilded in their aspect, and are covered in some cases by a fine silky down, which is supposed to prove useful to them when they fall into the water. Indeed, even in the perfect state, they are partly aquatic, and may be seen to seek repose and shelter on the under side of the leaf of a water lily, where they are necessarily submerged. According to M. A. Brongniart, the chrysalids are attached to their filaments by one edge only. M. Leon Dufour inclines to think, in consequence of anatomical investigation, that the Donaciæ ought to be formed into a particular family. His observations, as we are informed by M. Latreille, demonstrate that their hepatic vessels, in number, form, structure, and arrangement, constitute a very remarkable exception to those of the Tetramera in general, and one which even appears peculiar to the genus. These vessels only open into the chylific ventricle, while in all the other Tetramera which M. Dufour has dissected, they have two insertions, one of which is ventricular, and the other cæcal. These biliary ducts, which are only four in number, are of two different kinds, —the first are capillary, and disposed in two strongly flexed curves, and are inserted by four distinct ends into a short obround vesicle placed at the inferior and somewhat lateral extremity of the chylific ventricle,—the others are much shorter, thicker, more dilatable, thin, and tapering at both ends, with one extremity free, and separately inserted by the other into the superior and dorsal region of the ventricle. They contain a whitish pulp, which is regarded as an alimentary substance. The œsophagus is capillary, and has no dilatation in the form of crop. The chylific ventricle is beset with projecting papillæ.[4] Britain produces above twenty species of Donaciæ—a great amount, when we consider that Dejean's Catalogue contains only twenty-six in all. The genus may be regarded as characteristic of Europe, for scarcely any occur in other countries, although a few have been collected in America.

The genus CRIOCERIS properly so called, differs from the preceding in the posterior legs being scarcely, if at all, larger than the others. The antennæ become somewhat enlarged towards the extremity, are almost granose, with their articulations not much longer than broad. The eyes are elevated and emarginate, and the posterior extremity of the head forms a kind of neck behind these latter organs. These insects are of small size, their bodies narrow and elongated, and frequently ornamented with lively colours. They live on the leaves of various plants,—Liliaceæ, Asparagi, &c. and occur in gardens and meadows. When seized they produce a sharpish sound, by rubbing the superior extremity of the abdomen against the inferior extremity of the elytra. The larvæ feed on the same plants as those on which we usually find the perfect insects, and are somewhat adhesive or tenacious by means of their six scaly feet. Their bodies are soft, short, and inflated; and they protect themselves in that early state from the action of the sun and the changes of the season, by covering their backs with their own ordure. They occupy a subterranean position in the nympha state. The species are extremely numerous as the genus was originally constituted, but it has been greatly restricted in recent times. Mr Stephens gives seven as the amount of British species. Of these not above three have yet been found in Scotland. *C. asparagi* was taken near Edinburgh by Sir Patrick Walker.

In others the mandibles, instead of tapering to a point, as in the two preceding genera, are truncated. The palpi are terminated by a strongly inflated joint, truncated, with a small angular prolongation, exhibiting the appearance of another joint. The antennæ are slender, and composed of very long and almost cylindrical articulations. Such is the genus MEGASCELIS of Dejean and Lat. (Plate CCXXVII. fig. 9), peculiar to South America.

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[1] From μεγαλοπους, *having large feet.*

[2] For their distinctive characters, see *Règne Animal*, t. v. p. 134–5.

[3] From κριος, *a ram*, and κερας, *a horn.*

[4] *Règne Animal*, t. v. p. 136.

FAMILY VI.—CYCLICA.

In this family the first three joints of the tarsi are still spongy, or furnished beneath with pellets, the penultimate joint divided into two lobes, and the antennæ filiform, or a little larger towards the extremity; but the body is usually rounded, with the base of the thorax as broad as the elytra in such (and these are few in number) as are of an oblong form. The exterior division of the maxillæ, in its narrow and almost cylindrical form, and darker colour, presents the appearance of a palpus; the interior division is broader and destitute of a scaly tooth. The ligula is almost square or oval, entire, or slightly emarginate. It appears from the anatomical researches of M. Leon Dufour, that the alimentary canal is at least thrice the length of the body in such of the genera as have been examined; that the œsophagus is usually inflated behind the crop; and that the chylific ventricle, or stomach, is generally smooth, at least throughout a great part of its length. The biliary apparatus resembles that of the Cerambycidæ and other Longicornes, in the number and double insertion of the vessels of which it is composed;—these amount to six, two of which (except in the genus Cassida) are for the most part shorter and more slender. The larvæ have six feet; their bodies are soft, and frequently coloured. They feed, like the perfect insect, on the leaves of plants, to which they adhere by means of a viscid humour. Some enter the earth prior to their assumption of the nympha state, while others undergo that change attached to the plants on which they feed, and partly encompassed by the exuviæ of the larva. The perfect insects are of small size, but they are frequently adorned by brilliant colours and metallic splendour. They are slow and timorous in their general movements, and when attempted to be seized, they closely fold their feet and antennæ, and drop to the ground. Several species are good leapers, and the females are extremely prolific. Latreille divides this family into three tribes, according to the mode in which the antennæ are inserted.

Tribe 1st, Cassidariæ.

These have the antennæ inserted on the superior part of the head, and approximate, straight, short, filiform, and almost cylindrical, or increasing gradually towards the extremity. The mouth, situate altogether underneath, and with very short almost filiform palpi, is sometimes arched (cintrée), sometimes partially received into the cavity of the præsternum. The eyes are ovoid or round; the legs contractile and short, with the tarsi flattened,—the lobes of the penultimate articulation entirely inclosing the terminal one. The body being flat beneath, these insects, by the disposition of their tarsi, are enabled to adhere closely to the surface of vegetation, and to remain there immoveable; in other respects the body is generally orbicular or oval, and is margined all round, or overlapped, by the thorax and elytra. The head is concealed beneath the thorax, or is received into its anterior emargination. The colours are extremely varied, and are distributed in the form of spots and radiated markings, in a manner delightful to look upon. The larvæ present a less inviting aspect, and have the instinctive habit of covering themselves with their own excretions.

In the old genus Hispa,[1] of Linn. the body is oblong, with the head entirely free or exposed, and the thorax trapezoidal. The mandibles have only two or three teeth; the external maxillary lobe is shorter than the internal, and the antennæ are filiform, and borne projecting forwards. These insects now form the genera Alurnus, Fab. (Plate CCXXVII. fig. 10), and Hispa properly so called (ibid. fig. 11).

The genus Cassida,[2] Linn. and Fab. (Plate CCXXVII. fig. 12), is distinguished from the preceding by the orbicular or almost ovoid form of the body, which, however, in a small number is nearly square. The thorax, more or less semicircular, or in the form of the segment of a circle, entirely covers and conceals the head, or incloses it in its anterior emargination. The elytra, often elevated about the region of the scutellum, project over the body. The mandibles are furnished with not fewer than four teeth, and the external maxillary lobe is at least as long as the internal. The name by which the insects of this genus are distinguished was no doubt bestowed upon them on account of a strongly marked character in their structure. The edges of the thorax and elytra overlap and protect the limbs and abdomen on all sides, and the head is also nearly covered and concealed by the prothorax. Many of the species are highly ornamental, and present pleasing combinations of green and golden hues, which, however, soon disappear or diminish in intensity after the death of the insect, but may be temporarily restored by the use of hot water. These insects are herbivorous in their habits, and are fond of artichokes and thistles. The structure and habits of the larvæ are rather singular, and have been studied and described by Goedart, Roesel, Réaumur, and Degeer. They are flattish, rather broad, and beset laterally by sixteen branched spines placed horizontally on each side of the posterior and superior portion of the body. At the base of these spines may be observed seven small cylindrical truncated tunnels, each placed on a distinct segment. These are probably the stigmatic openings. The head is small, of a corneous consistence, and presents four small tubercles on each side of its superior part, and only three on its inferior. These are regarded by Degeer as genuine eyes. Six scaly feet, terminated by a brown-coloured hook, sustain the body, which is terminated by a two-branched fork, curved over the back, and usually bearing a pile of excrementitious matter, under which the larva lies in part concealed. It can elevate or depress this "stercorareous parasol" at pleasure, for the varying purposes of shade or shelter. The nymph is shorter than the larva, broad, flattened, of an oval form, and surrounded by peculiar appendages. It has an ample thorax, terminated by a circular arch, and furnished with similar points or appendages. The legs and the segments of the abdomen are perceptible. It was in the aspect of one of these nymphæ that Goedart supposed he recognised a representation of the human figure surrounded by an imperial crown. The genus Cassida presents an immense amount of species. About twenty are indigenous to Britain, several more occur on the continent of Europe, and, including exotic species, Dejean enumerates 103 as the amount (in 1821) of his then splendid, and now (1834) unrivalled collection of Coleoptera.

Tribe 2d, Chrysomelinæ.

In this tribe the antennæ are inserted in front of the eyes, near their internal extremity, and are distant at the base. None of the species are capable of leaping. They form, in the earlier works of Fabricius, the genera *Cryptocephalus* and *Chrysomela*, of which we shall here notice the principal component parts, as modified by the systematic views of recent writers.

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[1] Perhaps from *hispidus*, shaggy.

[2] From *cassida*, a helmet.

The original genus Cryptocephalus[1] contained those Chrysomelinæ of which the head seemed plunged vertically into an arched or hood-like thorax, in such a way that the body, generally in the form of a short cylinder, or almost ovoid, and narrowed anteriorly, appears, when viewed from above, as if truncated in front, or deprived of the head. The terminal articulation of the palpi is always ovoid.

In some of these the antennæ are short, and pectinated or serrated from the fourth or fifth joint, as in the genus Clythra of Leach and Fab. of which *C. quadripunctata* (a *Chrysomela* of Linn.) may be mentioned as a well-known British species. It measures about half an inch in length, and has red elytra, with a pair of black spots on each. Its larva lives in a little coriaceous tunnel, which it drags along with it. We here place also the singular genus Chlamys[2] of Knock[3] (Plate CCXXVII. fig. 13), in which the upper surface of the body is extremely rugged and unequal. Nothing is known of the history or transformations of these insects, all of which, as far as yet observed, are natives of the new world, especially of Brazil, a region so remarkable for its entomological riches. In a state of repose they draw in their legs and antennæ close upon their body, and when not in motion are with difficulty recognised as living creatures. The species are few in number, and by no means common in collections. Mr Kirby has described a new species under the name of *Chlamys bacca*,—"Animal singulare, baccam rubicundam acinis constantem superficie rugoso simulans."[4] In the genus Lamprosoma[5] of Kirby (Plate CCXXVII. fig. 14), the body is almost globular, very smooth and convex, and the thorax extremely short, broad, gradually raised, and slightly lobate at the middle of its posterior margin.

In other groups, the antennæ, perceptibly longer than the head and thorax, are simple and filiform, or enlarged towards the extremity, or even terminated by a club,—in which case they are generally toothed like a saw, but only from the seventh joint. In several the body is oval, and narrowed in front. The last article of the antennæ is furnished with an appendage, so as to produce an appearance of twelve joints. In the genus Cryptocephalus properly so called, the body is cylindrical, and the thorax as broad as the abdomen throughout its length. The antennæ and palpi are of the same size throughout. We have above a score of species in Great Britain. In the genus Eumolpus of Kugelan the body is narrowed in front, and almost ovoid. The mandibles are of ordinary size, and the second joint of the antennæ is shorter than that which follows. Almost all of them are exotic, although a few are found in Europe, of which *E. vitis*, Fab. and certain others, are said to occur in England. According to Geoffroy, the larva of the last-named insect is extremely destructive to vineyards.

We now approach the second great genus of the present tribe, that called *Chrysomela* by Linnæus. Of its modern reconstruction we shall likewise present the reader with a general sketch. The body of these insects is usually ovoid or nearly ovular, with the head salient, projecting or merely inclined. The antennæ are simple, about half the length of the body, and most frequently granose, and insensibly enlarged. When the great Swedish naturalist established his extensive genus Chrysomela, he included within its somewhat too ample boundaries numerous groups, which the more precise observation and richer materials of later entomologists have caused to be erected into separate genera. It is thus that we owe *Erotylus*, *Colaspis*, and *Adorium* to Fabricius, *Eumolpus* to Kungelman, *Helodes* to Paykul, *Doryphora* to Illiger, and *Paropsis* to Olivier,—besides several others, to the origin of which we need not here particularly allude. Many of the species of this genus are among the most beautiful and highly adorned of all the insect tribes. Azure, and green, and gold, form their ordinary costume; and to that lustrous aspect, combined with their compact and rounded forms, they no doubt owe their title of *Chrysomela*, which in the Greek language signifies an apple of gold.[6] These insects are of small or medium size. Few of them measure more than half an inch in length, and the greater number do not equal that dimension. They are strictly herbivorous, and sometimes commit considerable ravages on agricultural and garden produce. The larvæ have in general six feet, an elongated body, beset with warts or tubercles, and terminated by a kind of nipple, which secretes a viscous fluid, used both in walking, and in order to fix the insect firmly before its conversion to the nympha state. Their transformations usually take place in the open air, in which case they are protected by the hardening of their natural envelope. Many of the species are gregarious, while others are solitary; and it is among the latter that such occur as undergo their metamorphoses under ground. We shall now enumerate the principal generic groups into which the old genus Chrysomela has been subdivided.

In some the body is always ovoid, or nearly oval, and furnished with wings; the palpi terminate in a point. These insects resemble the Eumolpi already mentioned, and differ from the ensuing Chrysomelinæ in their filiform antennæ, which are longer than half the length of the body, composed of elongated nearly cylindrical articles, of which the eleventh or terminal bears an appendage or false joint nearly half as long as the article itself. Such are Colaspis, Fab. which have no projection of the mesosternum; and Podontia, Dalman, in which that part projects in the form of a short and conical point, the end of which is received into a posterior emargination of the præsternum.[7]

In the following groups the antennæ are short, composed of articulations in the form of a reversed cone, or more or less nearly granose, and enlarged towards the extremity. The false joint or terminal appendage is very short and indistinct. In the genus Phyllocharis of Dalman there is no mesosternal projection; but in Doryphora[8] of Illiger (Plate CCXXVII. fig. 15), that part is advanced like a distinct horn. The former genus inhabits New Holland and the island of Java,—the latter is peculiar to South America. The genus Paropsis,[9] Olivier, or *Notoclea* of Marsham (ibid. fig. 16), is distinguished from all the rest of the family by the maxillary palpi, of which the terminal article is much larger than the others, and hatchet-shaped. These insects, in so far as entomological research has yet extended, seem peculiar to New Holland. The two genera next ensuing interest our native naturalists as abundant over Britain. The terminal article of their palpi is also well distinguished from the preceding, to which it is equal, if not larger, in size,—its form being more or less semi-ovoid. These insects are widely spread over most parts of the ancient continent, especially Europe. In the genus TIMARCHA of Megerle and Dejean (Plate CCXXVII. fig. 17), the species are few in number, and apterous. The elytra are joined together, the body gibbous, and the tarsi much dilated, especially in the males. They occur on the ground in woods, fields, and by the sides of highways. Their movements are slow and heavy, and a yellowish or reddish liquor frequently exudes from their articulations. Linnæus classed a well-known species of this genus (*T. tenebricosa*) as a tenebrio. It has been dissected by M. Leon Dufour, and exhibited an intestinal tube three times the length of the body. It presented no appearance of a crop; and the stomach, which was long and folded on itself, contained no sensible papillæ: some small transverse muscular bands were just discernible. The stomach is followed by a filiform intestine, then by an oblong cæcum, bordering on the rectum. As far as our own observation has extended, the species, with a few exceptions from the north of Africa, seem confined to Europe. In the genus CHRYSOMELA properly so called (Plate CCXXVII. fig. 18), the species are all provided with wings, and the terminal article of the palpi is as large or larger than the preceding ones, and in the form of a truncated ovoid, or reversed cone. The species of this delightful genus are extremely numerous, even in its now restricted state. Comte Dejean was many years ago in possession of 120 species, and we know that his collection has recently been much augmented. Even in Britain we possess about thirty species, exclusive of fourteen kinds of *Phædon* and six of *Melasoma*, genera so nearly allied in structure and economy, that some authors do not yet distinguish them from the Chrysomelæ strictly so called. We regret that within our present limits we cannot describe the species. We shall merely mention that we lately received one of the largest and most beautiful, *C. fulgida*, from the valley of Clova in Forfarshire. It was previously unknown in Scotland. Another species of very exquisite aspect, *C. cerealis*, common in France upon the broom, has of late years been taken occasionally in Wales.[1] Our own collection is indebted for it to our liberal friend and valued correspondent Mr Melly of Manchester, a skilful and accomplished entomologist, and the owner of one of the largest and probably the best conditioned of the general cabinets of Coleoptera in Britain.

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[1] From κϱυπτος, *concealed*, and κεφαλη, *the head*.

[2] From χλαμυς, *a coat of mail.*

[3] *Neue Betrage zur Insectenkunde*, p. 122.

[4] *Linn. Trans.* vol. xii p. 446. Monographs of the genus *Chlamys* have been published both by Kollar and Klug.

[5] From λαμπϱος, *bright*, and σωμα, *body*.

[6] The word *chrysomelum*, from χϱυσος, *gold*, and μῆλεα, *an apple*, denoted in ancient times a fruit with a yellow rind, and was deemed by Linnæus sufficiently applicable to the insects of our present genus, on account of their rounded form and brilliant colouring.

[7] See Dalman's *Ephemerides Entomologicæ*.

[8] From δοϱυφοϱος, *a pike-bearer*, in allusion to the sternal spine.

[9] From παϱοψις, *a platter.*

Latreille terminates the tribe with such as have their maxillary palpi attenuated at the extremity, and ending in a point. These form two genera,—PHÆDON of Megerle, in which the body is ovoid or orbicular; and PRASOCURIS of Lat. (Plate CCXXVII. fig. 20).[2] Of the former, *C. fastuosa*, Linn. may be cited as a beautiful example, which occurs in great plenty at the base of Salisbury Crags and other places near Edinburgh, on the *Lamium album* or white dead-nettle,—of the latter, *P. Phellandrii* and *Beccabungæ* are well-known British species.

TRIBE 3D, GALERUCITÆ.

Characterized by the antennæ being always at least half as long as the body, of the same thickness throughout, or insensibly enlarged towards the extremity, inserted between the eyes, at a short distance from the mouth, and usually approximate at their base, and close upon a small longitudinal carina. The maxillary palpi, thickest towards the middle, are terminated by two joints of a conical form, but opposed or united by their base, the terminal one being either truncated, or obtuse, or pointed. The body is sometimes ovoid or oval, sometimes nearly hemispherical. Several, especially of the smaller kinds, have the posterior thighs very large, which gives them the power of leaping. They form the old genus *Galeruca*.

Latreille divides these insects into two principal groups, the *Isopodes*, or such as cannot leap, and the *Anisopodes*, or such as possess that faculty.

To the former belong the genera ADORIUM, Fab., of which the species are foreign; LUPERUS, Geoff., of which we possess two British species; and GALERUCA properly so called, of which our indigenous kinds are more abundant, and which is likewise extremely numerous both in Asia and America. *G. tanaceti* occurs in most parts of Britain. We took it in Sutherland. Java produces a very beautiful species, named *G. albicornis* by Dejean.

To the leaping Galerucitæ belong numerous insects, of which the posterior thighs are much enlarged. They were scattered by Fabricius through the genera *Chrysomela*, *Galeruca*, and *Crioceris*, and have been united by other naturalists under the single genus ALTICA.[3] Though of insignificant dimensions, their colours are varied and brilliant, their movements lively, and their powers of devastation considerable. They feed on the leaves of plants, and are familiarly known by the name of garden fleas. South America produces a great many species.[4] Many subdivisions have been proposed of the old genus just named. Of these, Latreille admits as established groups the genera OCTOGONOTES of Drapiez,[5] ŒDIONYCHIS, DIBOLIA, LONGITARSUS, Lat., and ALTICA properly so called. The last-named genus is the most frequent and best known in Britain. The species are of small dimensions, and occur in great numbers during the spring in humid places, and are extremely destructive both in the larva and perfect state to pot-herbs and other garden produce. The larvæ resemble those of Chrysomela and Crioceris, and some of them are remarkable for discharging an odorous and acid fluid from certain small tubercles on their backs. The nymphæ bear a likeness to those of Coccinella, and remain from fifteen to twenty days in that condition. The perfect insects are often highly adorned, and the species are extremely numerous. We shall mention merely *H. nemorum*, which is oblong-ovate, black, thickly punctured, with a longitudinal yellowish stripe on each elytron, the base of the antennæ, tibiæ, and tarsi testaceous. This species is but too abundant over all our country. "The chief dependence," say Messrs Kirby and Spence, "of our farmers for the sustenance of their cattle in the winter is

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[1] Certain species, of a darker or more obscure complexion than the others, form the genus MELASOMA of Dillwyn, so called from *μελας*, *black*, and *σωμα*, *body*. We may mention as an example, *M. populi*, the largest of the Chrysomelidæ hitherto found in Scotland. On each of the nine intermediate dorsal segments of the larva of this species there is a pair of black, elevated, conical tubercles, of a hard substance, from all of which when touched it emits a small drop of a white milky fluid, the smell of which, according to Degeer, is almost insupportable, being inexpressibly strong and penetrating. These drops proceed at the same instant from all the eighteen scent organs, which then present a singular spectacle. The precious fluid, however, is by no means wasted when exercised, for each drop, after a momentary appearance, during which it dispenses its perfume, is withdrawn again within its receptacle, till again required. (See Degeer, t. v. p. 291; and Kirby and Spence's *Introduction to Entomology*, vol. ii. p. 246.)

[2] *Helodes* of some other authors.

[3] From *αλτικος*, *a leaper*.

[4] We are indebted to Illiger for a monograph of these insects, published in the *Magazin für Insectenkunde*.

[5] *Annal. des Sciences Phys.* iii. p. 181.

Coleoptera Trimera.

another most useful root, the turnip; and they have often to lament the distress occasioned by a failure in this crop, of which these minor animals are the cause. On its first coming up, as soon as the cotyledon leaves are unfolded, a whole host of little jumping beetles, composed chiefly of *Haltica nemorum*, called by farmers the *fly* and *black jack*, attack and devour them; so that on account of their ravages the land is often obliged to be resown, and frequently with no better success. It has been calculated by an eminent agriculturist, that from this cause alone the loss sustained in the turnip crops in Devonshire in 1786 was not less than L.100,000."[1]

FAMILY VII.—CLAVIPALPI.

The insects of this family resemble the others of the same section in having the under part of the first three articulations of the tarsi furnished with brushes, and the penultimate bifid,—but they are distinguished from them by their antennæ, which are terminated by a distinct perfoliated club, and by their maxillæ armed on the inner side with a claw or corneous tooth. A few have the articles of the tarsi entire, but they still differ from other Tetramera with analogous tarsi, in their globular or ball-like form. In this family the body is usually rounded, frequently even very convex and hemispherical. The antennæ are shorter than the body, the mandibles emarginate or dentated at the extremity, and the palpi terminated by a large joint; the last joint of the maxillary palpi is very large, transverse, compressed, almost lunate. The form of the organs of manducation indicates that these insects are gnawers; and most of the European species occur on tree fungi, beneath bark, &c.

Some have the penultimate joint of the tarsi bilobed, and are not contracted like a ball. Of these, a certain number have the last article of the maxillary palpi transverse, and almost lunate or securiform. Such are the following genera. EROTYLUS,[2] Fab. (Plate CCXXVII. fig. 19), in which the intermediate articles of the antennæ are almost cylindrical, and the terminal club oblong. The corneous interior division of the maxillæ is terminated by two teeth. They are peculiar to South America.[3] TRIPLAX (*Triplax*, *Tritoma*, Fab.) differs from the preceding in the antennæ, which are almost granose, and terminate in a shorter and ovoid club. The interior division of the maxillæ is membranous, with a single small terminal tooth. The hemispherical or rounded species form the genus TRITOMA of Fab., while those of an oval or oblong shape constitute the genus TRIPLAX of that author.

The remainder of this little group have the last article of the maxillary palpi elongated, and more or less oval. Such are LANGURIA of Lat., of which the species are strangers to Europe; and PHALACRUS of Paykul (*Anisotoma*, Illiger and Fab.). The latter genus contains certain small shining hemispherical insects, frequently found on flowers. They pass the winter under moss or beneath the bark of trees, where they probably also undergo their metamorphosis. Their general colours are brown or black; their movements are rapid, and they are with difficulty seized or retained, on account of their smooth and polished surface. They differ from the last-named exotic genus, not only in their general form, but in the club of their antennæ being composed of three instead of five articulations.

In the remaining Clavipalpi all the joints of the tarsi are simple, and the body is almost globular. Such is the genus AGATHIDIUM, Illig. so named from *αγαθις*, *a clue*, probably in reference to the faculty possessed by the species of rolling themselves into a ball,—in which state they feign death in the most imperturbable manner. They occur in woods, beneath the bark of trees, and in mushrooms. We regard the genus, of which about a dozen species occur in Britain, as rather characteristic of the north of Europe. It was originally constituted by a dismemberment of Sphæridium, from which, according to the sectional system of Latreille, it stands at a great distance, having, in common with other *Tetramera*, only four articulations to all the tarsi. The same character, in this instance we fear an artificial one, also removes it widely from *Anisotoma*, *Leiodes*, and other genera with which it is, in all likelihood more naturally, conjoined by Mr Stephens and other English entomologists.[4]

TRIMERA.

Three Articulations to all the Tarsi.

This, the fourth primary section of the coleopterous order, consists of three families, of which the first two bear a strong relation to the concluding genera of the section we have just quitted. Their antennæ, almost always composed of eleven articulations,[5] terminate in a club formed by the three last joints. The club is compressed, and in the form of a reversed triangle. The first article of the tarsi is always very distinct; the penultimate is usually bilobed; and the last, presenting a knot at its base, is terminated by a pair of hooks. The elytra are not truncated, and entirely cover the abdomen. The genera of the third family, however, differ from the other two in the characters last mentioned, in which, as in several others, they make an approach to the Brachelytra, and other groups of the great pentamerous section. In their habits also they differ greatly from the rest of the trimerous families.

1ST, FUNGICOLÆ.[6]

These have the antennæ longer than the head and thorax, the body oval, with the thorax trapezoidal. The maxillary palpi are filiform, or slightly enlarged at the extremity, but not terminated by a comparatively very large and securiform article. The penultimate joint of the tarsi is always deeply bilobed. The genera are EUMORPHUS,[7] Weber (Plate CCXXVII. fig. 21), DAPSA, Ziegler, ENDOMYCHUS,[8] Web. (ibid. fig. 22), and LYCOPERDINA, Lat.[9]

2D, APHIDIPHAGI.[10]

Of the great majority of these the body is almost hemispherical, the thorax very short, transverse, nearly lunate. The antennæ terminate in a compressed obconical club, composed of the three last articles, and are shorter than the thorax. The terminal article of the maxillary palpi is very large and securiform, and the penultimate article of the tarsi is deeply bilobed. In the remainder of the family the articles of the tarsi are simple, or at least the penultimate is very slightly bifid, a character which, with certain others, distinguishes these insects from the Fungicolæ.

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[1] *Introduction to Entomology*, vol. i. p. 185.

[2] Ερωτυλος, *amorous?*

[3] See *Monographie du genre Erotyle*, by M. Duponchel, inserted in the twelfth volume of the *Memoires du Museum d'Histoire Naturelle.*

[4] For the Scottish species of these, and the allied genera, see *Entomologia Edinensis.*

[5] Latreille could clearly make out only nine in those of *Clypeaster*, but he thinks there may be some error in consequence of defective observation, arising from the minuteness of the species.

[6] From *fungus*, and *colo*, to inhabit.

[7] From ευμορφια, *elegance of form.*

[8] From ενδομυχος, *concealed within.*

[9] See *Règne Animal*, t. v. p. 160.

[10] From *aphis*, and *φαγος*, *eating.*

In the extensive and beautiful genus Coccinella, commonly called Lady-birds (Plate CCXXVII. fig. 23), the antennæ are distinctly composed of eleven articulations. The body is nearly hemispherical, the thorax very short, slightly if at all margined, and the penultimate joint of the tarsi is deeply bilobed. The head is not concealed. This genus was established by Frisch, and has been adopted by all succeeding entomologists. It serves, according to Mr Curtis, as a remarkable example of the value of structure in the combination of groups, and of the slight importance of the distribution of colour when employed to distinguish species. "As a genus, Coccinella is so natural that its appellation has never been disturbed; whereas the species composing it are so variable that many of them have been described under a great variety of names."[1]

These insects are distinguishable from the neighbouring genera of *Chrysomela* and *Erotylus* by the number of articulations of the tarsi, which never exceed three. In this character they so far coincide with *Eumorphus*, *Endomychus*, and *Dasycerus*,—but from those genera they differ in the shortness of their antennæ, the form of their bodies, and the development of the last articulation of the maxillary palpi. The general form of these beautiful, and for the most part familiarly-known insects, is hemispherical,—an aspect produced chiefly by the convex shape of the elytra. The under surface is extremely flat, and the legs are short, and, except when the insect is in motion, scarcely project beyond the lateral edges of the elytra. Leon Dufour has illustrated the anatomical structure of this genus with his accustomed accuracy. He discovered in *C. septempunctata* a salivary apparatus composed of three pair of diaphanous vessels, of extreme tenuity, more or less twisted, and extending from the hinder part of the mouth into the abdomen, where the extremities appear to float. He was, however, unable to detect the appearance of any gland or other organ of an essentially secreting nature; but when submitted to a powerful microscope, these vessels exhibited a structure entirely analogous to that of the salivary conduits observable in the dipterous and hemipterous tribes. A linear and tubular axis was perceptible through their pellucid coats, resembling that of the excrementitial secretions of the Carabidæ. The digestive canal is itself scarcely longer than the body of the insect, and is consequently nearly straight. The œsophagus seems inclosed in the head, in such a way that, to render it observable, the alimentary tube must be drawn backwards. The stomach is not preceded by any crop or gizzard. It is bilobed at its origin, where it approaches the head, and receives the œsophagus in the notch or slope produced by that bilobation. It is longer than the rest of the tube,—is very smooth and dilatable,—and was found filled sometimes with a blackish, sometimes with a yellowish pulp. Near its termination were the biliary vessels, six in number. These vessels are somewhat large in proportion to the size of the insect, and each has a distinct and isolated insertion on the stomach, like a cæcum. They have a very varicose aspect, and always appear diaphanous. The insertion of these biliary vessels indicates the limits of the stomach, and we have then a very short intestine, followed by a slightly bulged cæcum, and a rectum distinctly marked.

The larvæ of the Coccinellæ feed on Aphides, and are extremely useful in the destruction of those noxious insects which abound to the deterioration of so many valuable plants. In the perfect state many of the species pass the winter in the clefts of palings and the chinks of walls. Their eggs are usually laid in spring. These are of a yellow colour, with a disagreeable smell, and produce larvæ of an aspect very different from that of the perfect insect. In that early condition the body is much broader than deep, and is pointed towards the extremity, which bears a fleshy projection, carried by the insect on the plane of its position, and serving as a kind of supernumerary foot. The body consists of twelve rings or segments, which in some cases are garnished with spines or tubercles, in others smooth. When the larvæ have attained to their full size, they adhere by their hinder extremity to a leaf or a stone, and partly freeing themselves from a slough or skin, they assume the state of Chrysalis. In the course of a week or two, according to the species, the perfect insect makes its appearance. It is at first soft, flexible, and almost colourless, but a very short period suffices to adorn it with those gay and contrasted markings which render the Coccinellæ or "Lady-birds" among the most admired of all the smaller tribes of coleopterous insects. Some contrariety of opinion appears to exist in regard to the food and habits of these insects in the perfect state. Perhaps their instincts may vary according to circumstances, or may present a disparity in the species. We have frequently observed them preying upon Aphides; and yet Bosc, in describing the *Coccinella borealis* of America, mentions its destructive attacks upon the leaves of the melon plantations; and other species are said to be injurious to the crops of lucerne and cinqfoils. Their numbers vary greatly in different years. In 1807, as Messrs Kirby and Spence inform us, the shore at Brighton, and all the watering-places on the south coast, were literally covered with them, to the great surprise and even alarm of the inhabitants, who were ignorant that their little visitors were merely emigrants from the neighbouring hop-grounds, where in their larva state they had slain their thousands and their tens of thousands of the Aphis, which, under the name of the *Fly*, so frequently blasts the hop-grower's expectations.[2] Mr Stephens enumerates thirty British species of this genus, almost every one of which exhibits several striking varieties.[3]

In the remaining Aphidiphagi the body is very flat, in the form of a buckler, and the head is concealed beneath a nearly semicircular thorax. The antennæ do not seem to consist of more than nine articulations, and terminate in an elongated club. The articulations of the tarsi are entire. The præsternum forms anteriorly a kind of chin-cloth (*mentonnière*). Such is the genus Clypeaster, of which the species occur under stones, and beneath the bark of trees.

3d, Pselaphii.

This little family, in its short and truncated elytra, which leave the abdomen in part exposed, presents a cer-

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[1] *British Entomology*, vol. v. f. 208.

[2] *Introd. to Entomology*, vol. i. p. 257; and *Entomologia Edinensis*, p. 293.

[3] The natural union of these apparently distinct kinds may have given rise to the belief that different species of Coccinellæ cohabited with each other. "On trouve quelquefois," says Latreille, "des individus très différents par leurs couleurs accouplés; mais on n'a pas suivi les résultats de ces mélanges." (*Règne Animal*, t. v. p. 162.)

Orthoptera.

tain resemblance to the brachelytrous tribes, particularly the genus Aleochara.[1] The abdomen, however, is much shorter and wider, and is very obtuse and rounded posteriorly. The antennæ terminate in a club, or are enlarged towards the extremity, and sometimes consist of only six articulations. The maxillary palpi are usually very large. All the articulations of the tarsi are entire, and the first, much shorter than the following, is scarcely perceptible on a cursory examination; the last is frequently terminated only by a single hook. These insects occur upon the ground among vegetable debris. Some are found in ants' nests.

Such as have eleven joints to the antennæ form the genus PSELAPHUS[2] of Herbst (*Staphylinus*, Linn.), which is thus subdivided by Latreille. A limited number have two hooks to the tarsi. These form the genera CHENNIUM, Lat. (Plate CCXXVII. fig. 25), and DIONIX, Dejean. The remainder have only a single hook to the tarsi. Such are PSELAPHUS proper (ibid. fig. 24) of Lat., BITHYNUS, ARCOPAGUS and BRYAXIS of Leach, and CTENISTES of Reichenbach.[3]

The last of the Pselaphii, and with these we conclude the great coleopterous order, are distinguished by this peculiarity—that the antennæ are composed of not more than six articulations, and in certain cases (genus ARTICERUS of Dalman[4]) apparently of only one. In the genus CLAVIGER[5] (Plate CCXXVII. fig. 26) six joints are quite perceptible (ibid. fig. 27). These insects do not seem to have any eyes. The maxillary palpi are very short, without distinct articulations, and furnished with two terminal hooks. The first two articulations of the tarsi are very short, the third or last very long, with a single terminal hook. These insects occur beneath stones in dry situations.[6]

ORDER II.—ORTHOPTERA.[7]

In this order the wings are likewise four in number. The elytra or upper pair are softer and more flexible than in the preceding order; they are semi-membranous, reticulated, and for the most part do not form by their junction, when closed, a straight line along the dorsal suture. The true wings are folded longitudinally, and usually after the manner of a fan, and are divided by longitudinal membranous nervures. Maxillæ terminated by a corneous piece, toothed, and protected by the galea, a portion which corresponds to the exterior division of the jaws of coleopterous insects. In this order there is also a kind of tongue or epiglottis. The metamorphosis is semi-complete.

Linnæus arranged the first genus of our present order with his Coleoptera, placing it, however, by itself at the termination of that order;—the remaining genera were grouped with his hemipterous tribes. We owe their separation to Degeer, who formed the whole into an order, under the name of *Dermaptera*.[8] They correspond to the *Ulonata* of Fabricius. The title which they now bear was imposed by Olivier.

The body of orthopterous insects is generally of an elongated form, and of a somewhat soft and fleshy consistence. It is composed as usual of head, thorax, and abdomen. We shall briefly describe the general characters of these parts. The head varies considerably in size, form, and position. It is usually large and vertical, and presents in the greater number of species two or three stemmatic eyes. The front is sometimes prolonged into a conical form, as in certain species of the genera *Truxalis* and *Mantis;* sometimes it bears a kind of fleshy appendix resembling a veil, as in the *Gryllus umbraculosus* of Spain. The true eyes occupy the sides of the head, and are generally very large, with a reticulated aspect. The antennæ do not vary so greatly in their structure as among the Coleoptera, but they are usually composed of a greater number of articulations. They are generally inserted in front of the eyes, but sometimes beneath or between them. Their articulations are not very distinct, and as to shape they are filiform, setaceous, massive, perfoliated, and sometimes ensiform, or resembling the blade of a sword.

The mouth consists of a labrum, two mandibles, a pair of maxillæ, a labium, and four palpi. The labrum is attached to the clypeus by a distinct suture; it is moveable, always external, demi-coriaceous, somewhat arched or vaulted, almost semicircular, rounded in front, and advancing on the mandibles. The mandibles are scaly, or corneous and strong, triangular, short, thick, with the exterior side arched, and the interior armed with many unequal teeth or dentations. According to the observations of Marcel de Serres, these dentations bear a close relation to the mode of nourishment; and he distinguishes them, as we do the dental system of the Mammalia, as *incisive*, *canine*, and *molar*. These last are the largest, and there is never more than one in each mandible, placed towards its base. The three sorts of teeth never exist simultaneously, and it is by their presence or absence, and by the modifications of their forms, that we may recognise the nature of the various substances by which the different tribes of Orthoptera are nourished. In the genera *Mantis* and *Empusa*, for example, which are purely carnivorous, we find only the canine teeth or *laniares*. Those species which have only incisive and molar teeth are herbivorous, while such as are omnivorous possess canine and molar teeth, but of smaller dimensions. The maxillæ resemble in a great measure those of the carnivorous Coleoptera. They are very strong, corneous, at least on their superior portion, which forms a kind of large conical tooth, provided with two or three dentations. They also bear

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[1] The *Pselaphidæ* of Mr Stephens form the first family of his *Brachelytra.* (*Nomenclature of British Insects*, 2d edition, col. 89.)

[2] From *ψηλαφάω*, *to feel one's way.*

[3] For the details of the above genera, of which we can only indicate the names, see Reichenbach's *Monographia Pselaphorum;* the 3d vol. of Leach's *Zoological Miscellany;* the 4th of Gyllenhal's *Insecta Suecica;* the article *Pselaphiens* of the *Encyclop. Méth.;* and the *Règne Animal*, vol. v. p. 164.

[4] Memoir (in Swedish) *On the insects inclosed in amber*, p. 21.

[5] *Claviger*, a club-bearer. See a Monograph of the genus by Müller, in the 3d vol. of Germar's *Magazin der Entomologie.*

[6] Two additional primary sections of the order Coleoptera were formerly recognised, under the names of DIMERA and MONOMERA. These are now suppressed, for the reasons assigned at page 110 of this article.

[7] ULONATA, Fab.

[8] The order now known under the name of *Dermaptera*, and admitted as such by many modern writers, is an osculant one, connecting the *Coleoptera* and *Orthoptera*, and is composed of the genus *Forficula.* The elytra are of a coriaceous consistence, without veins, have a straight suture, and inclose wings which are folded longitudinally as well as transversely. These characters serve to connect it with the preceding order, while the form of the wings, the organs of the mouth, and the nature of the metamorphosis, exhibit its alliance to the orthopterous tribes, along with which we have consequently ranked it in the present treatise, in conformity with the views of M. Latreille, although we are aware that most English entomologists, and many foreign ones, prefer that it should be distinguished as above mentioned.

Orthoptera.

two palpi, but that which is named the internal palpus among the carnivorous Coleoptera is here transformed into a membranous inarticulate piece, sometimes cylindrical, in other instances triangular or dilated, but in all cases vaulted above, and covering the extremity of the maxillæ. It is to this particular portion, or internal maxillary palpus, that Fabricius applied the name of *galea*, or helmet, a term not very accurately translated *galette* by Olivier. The external maxillary palpi, which alone are apparent, are composed of five articulations, of which the two first are extremely short; and it is in these palpi that Olivier and Marcel de Serres suppose themselves to have discovered the organ of the sense of *smell*. The latter author observed in their interior a pair of nerves spreading themselves over the vesicular membrane which terminates their last articulation. These he names the olfactory nerves: one is furnished by the fifth pair, which springs from the inferior face of the brain, and the other by the first pair, which derives its origin from the lateral and superior face of the first ganglion of the head. Between these two nerves there is a trachea, which, before it reaches the vesicular membrane, commences to form a pneumatic pouch. This pouch is more fully developed in the interior of the palpus, and throws off numerous ramifications, which spread themselves within the cavity of the organ. It was this peculiar structure which induced Olivier and Marcel de Serres to regard these palpi as the organs of the sense of smell. We may add, however, that Latreille is by no means satisfied that they are so, and thinks that additional observation is necessary to establish this alleged fact in the physiology of insects. The labium, or ligula, of the Orthoptera, is almost membranous, elongated, slightly enlarged towards its extremity, and divided into two or four stripes or portions.

The interior of the mouth exhibits an additional piece, which some regard as a tongue; it is fleshy, longitudinal, carinated above, broader at its base, slightly restricted before its anterior extremity, rounded, immoveable, and somewhat notched at its point. The mentum is coriaceous, in form of a transverse square, rather narrow towards the summit. The labial palpi are composed of only three articulations, as among the coleopterous tribes.[1] Those of the maxillæ consist of five.

The thorax is composed, as in other cases, of a prothorax, a mesothorax, and a metathorax. The first is generally the largest, and is the only part exposed. It presents a great variety of forms, some of which are sufficiently singular. The elytra, in the greater number, are coriaceous, thin, flexible, semitransparent, and reticulated. They are occasionally almost horizontal, with a straight dorsal suture, as among the Coleoptera; but they are much more frequently more or less inclined, with their inner edges crossing each other when closed over the back. The true wings are broader than the elytra, membranous, full of reticulations, and longitudinally folded after the fashion of a fan. To this latter character, however, the somewhat anomalous genus *Forficula* (containing the earwigs) presents an exception, as in it the wings are also transversely (as well as longitudinally) folded, as among the Coleoptera. In some cases the females, and in a few instances both sexes, among the Orthoptera, are destitute of wings. In many species the elytra of the males are short or rudimentary, and in that sex also a portion of the inner margin of these parts frequently resembles talc or parchment, and exhibits large irregular nervures. It is by the rapid friction of these upon each other that the monotonous song, or *stridulation* as it is called, of many species is occasioned. In others, however, a shrill monotonous cry is produced by rubbing the posterior limbs against the edges of the elytra.

The legs of orthopterous insects are sometimes similar to each other. In other cases the anterior pair are more extensile, and are armed with spines, with which they transfix their prey,—or they are dilated, compressed, strongly toothed externally, and adapted for burrowing in the earth. The posterior legs, as among locusts and grasshoppers, are frequently much larger than the others, and fitted for powerful leaping; and both the middle and posterior pair are more widely apart from each other at their origin than among the coleopterous species. The articulations of the tarsi differ in the different tribes; but we believe that no *heteromerous* species have been yet observed. These articulations are not unfrequently furnished beneath with little membranous cushions, and the terminal articulation is always provided with a pair of hooks or claws.

The form of the abdomen varies in this order. It is divided externally into eight or nine rings, and is often terminated by projecting appendages. Many of the females are furnished with an ovipositor, composed of two portions closely applied, and frequently surrounded by a common envelope.

In relation to the anatomy of the Orthoptera, we may state, that they are all characterized by a first membranous stomach or crop, succeeded by a muscular gizzard, armed interiorly with scales or corneous teeth, according to the species. Around the pylorus, except in the *Forficulæ*, are two or more blind intestines, furnished at their base with many small biliary vessels; and numerous other vessels of a similar nature are inserted towards the middle of the intestine. The digestive system of the larvæ resembles that of the perfect insect.

M. Marcel de Serres has particularly devoted himself to the study of the internal structure of these creatures. He informs us that the Orthoptera with setaceous antennæ, such as the genera *Blatta*, *Mantis*, *Gryllo-talpa*, *Gryllus*, and *Locusta*, have only elastic or tubular tracheæ, and these of two kinds,—the one arterial, the other pulmonary. The latter alone distribute the air to all parts of the body, after having received it from the former. In the genera characterized by cylindrical or prismatic antennæ, such as *Acrydium* and *Truxalis*, the pulmonary tracheæ are replaced by vesicular ones. They are covered by cartilaginous hoops or moveable ribs, and receive air by means of tubular or elastic tracheæ, which proceed from the arterial kind. According to the same authority, the nutritive system is more or less developed, and exhibits four principal modifications. *Gryllus* and *Gryllo-talpa* in that respect excel the others. In them the crop is shaped like a bagpipe, and placed on one side, while in the rest it is on a line with the gizzard. In the latter also the hepatic vessels are inserted insulately, but in the former by means of a common deferent canal. The genera *Truxalis* and *Acrydium* (criquets), although resembling *Locusta* (*Sauterelles*) in their digestive system, differ in respect to the superior hepatic vessels, which are not furnished at their extremity with secreting vessels, and no longer form enlarged pouches, but cylindrical and elongated canals. The intestines of *Blatta* and *Mantis* present only two divisions; their nutritive system is in other respects the same. The *Forficulæ*, of which Mr Kirby and Dr Leach form a distinct order under the title of *Der-*

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[1] This characteristic is assigned by Latreille (*Règne Animal*, t. v. p. 168) and other writers; but we have ourselves detected four articulations in the labial palpi of several genera.

maptera, do not appear to have been investigated by Marcel de Serres.[1] According to Baron Cuvier, they differ from all other Orthoptera in wanting the superior hepatic vessels.

The metamorphoses of the Orthoptera are called semicomplete, and consist chiefly in the development and increase of the elytra and wings. Both the larvæ and nymphæ feed and move about like the perfect insects, and differ chiefly by the entire want of wings in the first state, and their rudimentary condition in the second. These insects lay an immense number of eggs, of an elongated form and considerable size. They are sometimes deposited in a mass, and inclosed together within a capsule. Both young and old are extremely voracious, and frequently produce the most frightful consequences by their devastations. On the other hand, we are not aware of any recompensing advantages derivable to the human race from any species of orthopterous insects. Several eastern tribes no doubt use them as food, and seem to have done so in remote times, as indicated by the ancient name of *Acridophagi;* and the sacred writings have recorded that the food of John the Baptist in the wilderness was "locusts and wild honey." We believe that no aquatic species is contained in this order.

Mr Macleay has observed, that although there may be reason for hesitation with respect to the types of the Neuroptera, there is none in relation to the principal forms of the orthopterous order. These forms seem to have been perceived by all entomologists, and their dissimilarity has led to tribes being regarded in the light of orders. "Indeed no forms that are within the limits of an order can be more distinct from each other than those of a *Phasma, Truxalis, Locusta, Acheta, Blatta*, and *Forficula;* and we accordingly find that they have been considered as the types of so many groups by Linnæus. The affinity of *Blatta* to *Mantis* is acknowledged in the *Règne Animal.* The genus *Proscopia*, lately instituted by Professor Klug of Berlin, one of the first entomologists of the present day, proves the proximity of *Phasma* to *Truxalis;* and no entomologist is ignorant that the chain of connection from *Acridium* to *Locusta*, from *Locusta* to *Acheta*, and from this to *Blatta*, has been long since detected, and is now perfectly established. Hence some notion may be obtained of the contents of the orthopterous circle, if we reckon the above-mentioned five genera as the types of the following tribes:

1. Phasmina.
2. Acridina.
3. Locustina.
4. Gryllina.
5. Blattina.

But as this series returns into itself, and the genus *Forficula* cannot be inserted therein without disturbing its regularity, we must agree with Degeer and Mr Kirby, that it belongs to a distinct order. That this order can only be esteemed osculant between the *Orthoptera* and *Coleoptera*, the reader will perceive by referring to its place in the *Systema Naturæ.* The *Dermaptera*, for so they are termed, from its having been the name originally proposed for the *Orthoptera* by Degeer, are in fact coleopterous insects, with the metamorphosis and caudal appendages of the true *Orthoptera*."[2]

This is a much less numerous order than the preceding, in the amount at least of the ascertained species, and in Great Britain we have not above sixty different kinds.

FAMILY I.—CURSORIA.

All the feet formed for running. Wings and wing-cases almost always placed horizontally on the body. Females unprovided with a corneous ovipositor.

GENUS FORFICULA. Tarsi triarticulate. Wings folded like a fan, and refolded transversely beneath the elytra, which are extremely short, with a straight suture. The body is linear, and terminated by two moveable scaly pieces, in the form of a pair of pincers. Head exposed. Antennæ filiform, inserted before the eyes, and composed of from twelve to thirty articulations, according to the species. The ligula is forked.[3] See Plate CCXXVIII. figs. 3, 4, and 6.

The insects of this genus, known under the familiar name of *earwigs*, are frequent in moist places, beneath stones, under the loose bark of old trees, or in decayed timber. They are injurious in gardens, where they attack various kinds of fruit. They also pierce the petals of flowers, and do not refuse animal food. Our entomological cabinet, when left open for a summer night, has sometimes suffered from their depredations. They may therefore be regarded as omnivorous. Their alleged inclination to enter the *ear* is a vulgar error, not derided however even by the Swedish sage:—"Aures dormientum interdum intrans," says Linnæus, "spiritu frumenti pellenda."

We shall not here describe the species, as their general appearance must be familiar to the reader; but we shall devote a few lines to the manners of the common earwig, *F. auricularia.* The female is known to watch over her eggs with great care,—an uncommon tendency among insects. Degeer placed an earwig, with her eggs, in a box with fresh earth, early in the month of April. They had been scattered by accident about the box; but she soon collected them together, and placed herself above them, as if she were hatching. Towards the middle of May the young made their appearance. They seemed large in proportion to the eggs, and appeared as if swollen. The movement of the dorsal vessel was very perceptible through the skin. These larvæ have neither wings nor elytra. They are composed of thirteen segments, of which the first three bear the legs, and the last exhibits the germ of the pincers, which are conical and slightly divergent. The antennæ are composed of eight articulations. Degeer endeavoured to bring up the young along with their mother, and fed them with slices of apple. They were observed to cast their skins several times, and after each of these changes the antennæ gained an additional articulation. The pincers also became longer, and their points approached each other, as in the adult insect. These larvæ, however, all perished by degrees but one; and the mother also perished, and was found half devoured by her offspring, an ungrateful return for such tender solicitude. This unnatural voracity, however, probably arose from a deficiency of other food, as they are never observed to attack each other in a state of freedom. The remaining larva increased in size, and assumed the nympha state towards the end of July. The cases of the elytra and wings are flat, and closely pressed upon the back, and the pincers have assumed their usual aspect. It therefore does not greatly differ from the perfect insect.

The genus contains many species, and is widely distributed. Several sub-genera have been instituted by Dr

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[1] They have since been examined by M. Dufour. See the note of the ensuing page.

[2] *Hor. Ent.* p. 435.

[3] For the details of internal structure of this genus, see the *Mémoire sur l'Anatomie des Labidoures*, by M. Dufour, in the 13th vol. of the *Annales des Sciences Nat.*

Orthoptera.

Leach and others; but the nature of our present article does not admit of our taking cognisance of those minor groups.

Genus Blatta. Tarsi with five articulations. Wings folded only in a longitudinal direction. Head concealed beneath the shield of the thorax. Body oval or orbicular, and depressed. Antennæ setaceous, inserted in an internal notch of the eye, and composed of a great number of articulations. Palpi long. Thorax shield-shaped. (Plate CCXXVIII. fig. 7.)

The elytra of these insects are usually as long as the body, coriaceous or semi-membranaceous; and when closed, cross each other a little at the suture. The posterior part of the body is furnished with two conical and articulated appendages. Their crop is longitudinal, their gizzard furnished interiorly with strong hooked teeth, and there are from eight to ten cæca around the pylorus.

The Blattæ, or *cockroaches*, as they are called in this country, are nocturnal insects, which seldom fly, but run with great rapidity. Some inhabit woods or the crevices of old walls, while others frequent store-rooms and dwelling-houses, where their voracious propensities produce great damage to all kinds of provisions. They likewise destroy silk and woollen stuffs, and even leather. But their ravages are chiefly confined to warm countries. The species are numerous. Olivier[1] has described thirty-seven; and many have been discovered since his time. The *Blatta orientalis* of Linn. is about an inch long, of a reddish chesnut-brown. The wings, which are shorter than the abdomen in the male, are merely rudimentary in the female, and are wanting in the larvæ of both sexes. The eggs, to the number of sixteen, are inclosed symmetrically in an oval compressed shell, which is at first white and afterwards brown. It is tolerably solid, and is toothed along its edges like a saw. The female carries it about with her for some time, and afterwards attaches it to a favourable position, by means of a gummy exudation. This species, originally imported from eastern countries, is now widely spread over Europe, and occurs as far north as Finland.

The *Blatta Americana* of Linn. is a native of South America and the Antilles; from whence it was imported into Asia and Africa, and from these to European countries, where it chiefly infests sea-port towns, preying on sugar and other colonial produce. Sonnerat has described its combats with *la Mouche verte*, a brilliant fly of the family of Ichneumonidæ. The thorax of this species is yellowish, with two spots and a border of brown. It may also be known by the great length of its antennæ.[2] Including foreign importations, we have now twelve species of the genus Blatta in Britain.

Genus Mantis,[3] Linn. Tarsi with five articulations. Wings folded longitudinally. Head not concealed. Body narrow and elongated. Palpi short, and ending in a point. Ligula quadrifid.

We may observe, that the genus *Mantis*, as originally constituted by Linnæus, contained a great variety of very singular and somewhat incongruous forms. It has since been greatly restricted, and more precisely defined, by Illiger, Latreille, Lichtenstein, and other modern writers. Thus it is distinguishable from *Empusa* of Illiger, by the antennæ, which in the latter genus are pectinated in the male sex, and by the want of the frontal prolongation of the head. From the spectre insects (*Spectrum*) with which they were likewise combined by Linnæus, the true species of Mantis may be easily discriminated by the form and relative length of the legs, which in the spectres are of uniform size. The head in Mantis is triangular, vertical, with large eyes, and three small distinct stemmata. The antennæ are simple, setaceous, inserted between the eyes, and composed of numerous articulations. The labrum is entire; the mandibles cutting or incisive; the palpi filiform, pointed, not compressed; and the ligula is composed of four parts or divisions of nearly equal length. The thorax is long, and composed almost entirely of the first segment, of which the anterior extremity is frequently dilated, and the sides rounded. The first pair of legs are held in advance and raised, the haunch being very large, and the thigh toothed and compressed; the tibia is also toothed, and terminated by a strong hook or crotchet. The other legs are slender, simple, and unarmed with teeth or spines. The elytra are horizontal, narrow, lengthened, rather thin, semitransparent, and overlap each other on their inner edges. The under or true wings are folded lengthways like a fan. The abdomen is oblong, and is terminated by two conical articulated appendages, and a compressed scaly plate, arched on the back, and composed of several short pieces received into a pair of anal valves.

Such, we conceive, are the characters of the genus Mantis properly so called. It contains a considerable number of species, all characterized by singular and eccentric forms. We do not know by what means it has happened that an insect of this genus has become, in various parts of the world, if not an object of religious worship, at least a subject of superstitious wonder and credulity. From time immemorial the Mantis, in Turkey, has been regarded as a sacred insect; and even among the apathetic Hottentots, so sparingly endowed with any thing allied to the nobler faculties, it is said to be held in still higher estimation. The *Mantis religiosa* of Europe, called *Prega-Diou* (Prie-Dieu) in the southern provinces of France, is well known as living habitually under the safe-guard of a religious veneration on the part of the peasantry, who deem it a faithful guide and guardian of children who have lost their way. It has obtained the name of *religiosa*, from the incessant movements of its fore legs, which it is continually raising into the air, and as it were clasping together. This action, however, is the result of its peculiar instinct and mode of life; for the insect, in common with the rest of the genus, is a fierce, cruel, gormandising creature, and so far from indulging, as is fondly supposed, in a state of religious abstraction, is continually seeking for what it may devour. It preys upon all the weaker insects, which it either crushes to death, or relentlessly impales alive upon the sharp spines of its own shanks. To effect this, it is perpetually moving its arms or fore-legs in the air, and closing one armed joint upon another, so that whatever insect prey approaches within its reach is immediately transfixed and devoured. In some of the French provinces it is called the *sorcerer*. Four or five different species are found in Europe, and many more occur in the warmer regions both of the old world and the new.

In the nymph or intermediate state, the Mantides are as active and voracious as the perfect insect. Following the footsteps of Rossi (author of the *Fauna Etrusca*), the writer of the present treatise has frequently watched their manœuvres on the plains of Pisa, and has more than once had occasion to regret the loss of rarer captures, in consequence of their indiscriminate voracity.

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[1] *Encyclopédie Méthodique*, t. iv.

[2] For the other species, consult Degeer's *Memoires*, t. iii.; *Encyclop. Méthodique*, t. iv.; Fuessly's *Archives des Insectes*, tab. 49, 2–11; Coquebert's *Illust. Icon. Insect.* iii. 21, 1; and the *Horæ Entomologicæ* of M. Toussaint Charpentier, p. 71–78.

[3] From μαντις, *a prophet* or *soothsayer*.

But he cannot say that he ever confirmed the observation of Roesel.[1] On the back of the nymph there are four lamina or flattened cases, which contain the germs of the wings and elytra. The eggs are deposited in a lengthened mass of two rows, and protected by an envelope somewhat of the consistence of parchment. They are of a yellow colour and elongated form, and are usually attached by the female to the stalk of a plant.[2]

Such as have the front prolonged in the form of a horn, and in which the males are provided with pectinated antennæ, form the genus Empusa[3] of Illiger. Their limbs are furnished with rounded membranous appendages resembling ruffles, and in several the edges of the abdomen are festooned. (Plate CCXXVIII. fig. 1.)

Others have the anterior legs similar to the rest; the stemmatic eyes indistinct or non-existent; the first segment of the thorax shorter or not longer than the following one; the interior divisions of the ligula shorter than the lateral; the antennæ inserted before the eyes, and the head almost ovoid and advanced, with the mandibles thick and the palpi compressed. These form the genus Spectrum,[4] Stoll, which has since been divided into two,[5] both of which are truly remarkable for the singular adaptation of their form and colour to such productions of the vegetable kingdom as they most affect. The sexes often differ greatly. 1*st,* In the genus Phasma[6] of Fabricius (Plate CCXXVIII. fig. 5), the body is filiform and linear, and resembles the stem of a plant or the twig of a tree. Several are entirely apterous, or have extremely short elytra. Very large species occur in the East Indies, the Moluccas, New Holland, and South America. *P. gigas* measures nearly a foot in length. The body is green, tuberculated on the thorax; the elytra very short and likewise green; the wings are large, of a reddish-grey, reticulated, with numerous bands and spots of brown, and with a large lateral space of a coriaceous texture and greenish colour. The legs are spinous. It occurs in the East Indies. *P. Rossi*, a much smaller and apterous species, occurs in the south of France. 2*d*, In the genus Phyllium[7] of Illiger (Plate CCXXVIII. fig. 2), both the body and legs are flattened and membranous, and the first segment of the thorax is cordiform. The wings and elytra vary in their degree of development in the different species, but they frequently cover the abdomen in such a manner as to make it appear as if two leaves had fallen upon the insect. Some seem green and fresh, others brown and withered, while an intermediate kind present the red and yellow hues of autumn. This imitation, or rather representation, of the vegetable kingdom, is indeed so singular as to attract the attention and excite the astonishment of the least curious inquirer; and it is in reference to the peculiar character just mentioned that these insects are known by the name of *walking leaves.* According to some authors, the antennæ of the males are long, slender, setaceous, and composed of a great number of nearly cylindrical articulations,—while those of the females are shorter than the head, conical, granular, and composed of not more than nine articulations. It appears that this great disparity between the sexes led Latreille into an error when he formed a distinct species of *Ph. longicornis*, which is in fact the male of *Ph. siccifolia.* The latter (see the figure last referred to) is fully three inches long, very flat, and of a pale yellowish-green colour. The thorax is short and dentated on the sides, and the foliations of the thighs are likewise dentated. In the female the antennæ are very short, the elytra as long as the abdomen, and the true wings wanting. The form of the male is narrower and more lengthened, and the antennæ long and setaceous; the elytra are short and the wings long. This species, Latreille informs us, is raised by the inhabitants of the Sechelles Islands as an object of entomological commerce. The same species, and some others nearly allied, occur in India, and the great eastern islands, such as Java, the Celebes, &c.

FAMILY II.—SALTATORIA.

Posterior legs very strong, spiny, and formed for leaping.

The males of this family (which corresponds to the great genus *Gryllus* of Linn.) are musical, that is, provided with the power of producing peculiar sounds, by friction of certain parts of their structure upon others. Most of the females deposit their eggs in the earth.

Genus Gryllus. Tarsi with three articulations. Elytra and wings horizontal, the latter folded longitudinally, and forming, when closed, a slender thread-like acumination beyond the elytra. Antennæ setaceous, inserted between the eyes. Ligula with four divisions, of which the central are very small. Labrum entire, with a projecting slip in that of the female.

This genus contains the insects commonly called crickets. They inhabit both fields and dwelling-houses. The common species (*G. domesticus*, Linn.) (Plate CCXXVIII. fig. 9) is of a pale yellowish or clay colour, mingled with brown. The female bears a long ovipositor, and the male is characterized by his perpetual cry of *cree cree*, uttered most continuously during warm weather, or in the vicinity of ovens or large kitchen fires. These insects remain in their retreats during the day, and come forth in the night season to seek their prey. They feed on bread, flour, and other articles of domestic economy. Latreille says they also devour insects. The common cricket is widely distributed over Europe. In Spain it is kept by the peasantry in little cages hung by the fireside, for the sake of its song.

The field cricket (*G. campestris*) is larger than the preceding. It is of a blackish hue, with the base of the elytra yellowish. The head is large. The posterior thighs are red beneath. The female, during the month of July, lays about three hundred eggs, from which the young are excluded in fifteen days. They feed on herbs and roots, and moult or change their skins before winter. During that inclement season they lie torpid under ground, and re-appear in spring. The larvæ are apterous, the nymphæ bear the rudiments of wings and elytra, the perfect insects, which possess the power of flight, are manifested in June and July. This species inhabits Africa and all the southern countries of Europe, where the peasant children are in use to *fish* for it, by holding an ant fastened to a hair over its hole. It is foolish and fearless, and will leave its retreat if even a stalk of grass is inserted in its dwelling; hence the French expression of *sot comme un gryllon*. It occurs in England, and we heard its song near Edinburgh for the first time last summer (1833).

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[1] "Il a conservé des Mantes en les nourissant avec des mouches ou autres insectes; quand on les mets ensemble elles se dévorent. Un mâle et une femelle de ces insectes ayant été enfermés dans un vase de verre, le premier fut saisi par la femelle, qui lui coupa la tête. Comme ces insectes sont extrêmement vivaces, le mâle vécut encore assez long-temps, et ne fut dévoré par la femelle que quand celle-ci en eut été fécondée." (Guerin.)

[2] For the species of this and the ensuing genera, see Stoll's *Representation des Spectres, des Mantes*, &c.; Lichtenstein's *Monograph*, in the sixth volume of *Linn. Trans.*; and other works.

[3] From εμπουσα, *an apparition.*

[4] From *spectrum*, a spectre or ideal form.

[5] Other minor divisions have been effected at a still more recent period, by MM. Lepelletier and Serville (in the *Encyclop. Méth.*), and by M. Latreille in his *Familles du Règne Animal.*

[6] From φασμα, *a prodigy.*

[7] From φύλλον, *a leaf.*

There are many very singular insects belonging to this genus. The *Gryllus umbraculatus* occurs in Spain and Barbary. The male is remarkable for a membranous prolongation of the head, which falls over it like a veil. India produces the *G. monstruosus*, of which the elytra and wings are spirally twisted at their extremities. A new and large species has been lately discovered in Sicily by MM. Lefevre and Bibron, and described by them under the name of *G. megacephalus*. Of this insect each particular cry, instead of being momentarily repeated, is prolonged for about half a minute, and may be heard at the distance of a mile.

We shall here briefly notice some of the allied genera. The mole-cricket now forms the genus GRYLLO-TALPA[1] (Plate CCXXVIII. fig. 8), of which the tibiæ and tarsi of the two anterior pair of legs are flattened and toothed, and so constructed as to serve for throwing back the earth while burrowing. These insects are destructive in gardens and cultivated fields, by detaching or cutting asunder the roots of plants, during the progress of their subterranean excavations. Their natural prey, however, consists of insects and worms. The female of the best known species (*G. vulgaris*, Lat.) lays from two hundred to four hundred eggs in a commodious dwelling under ground, resembling a bottle with a curved neck. The young dwell together for some time in society. The song of the male is sweet and agreeable.[2]

An insect found in the south of France by the sides of rivers, a strong leaper, of small size, and of a black colour, spotted with yellowish-white, belongs to the genus TRIDACTYLUS[3] of Olivier, characterized by having the anterior pair of legs only formed for digging. In place of the posterior tarsi, there are moveable appendages in the form of claws. The antennæ are short, of equal thickness throughout, and composed of ten articulations. The species above alluded to is the *Xya variegata* of Illiger. Charpent. *Horæ Ent.* p. 84, t. ii. fig. 2, 5.

A singular species, misnamed *Blatta acervorum* by Panzer, takes up its abode in ants' nests, and now forms a genus of our present group under the name of MYRMECOPHILA.[4] The body is oval and apterous, the posterior thighs very large. In the antennæ, and the want of stemmatic eyes, it resembles *Gryllus* properly so called.[5]

GENUS LOCUSTA. Tarsi with four articulations. Elytra and wings inclined. Antennæ very long and setaceous. Mandibles less dentated, and galea larger than in Gryllus. Females provided with an ovipositor compressed in the form of a sabre or cutlass.

These insects are herbivorous. They occur in grassy meadows, and on shrubs and trees. In flying they spring into the air, and then extend their capacious wings, but their flight is neither rapid nor long sustained. The cry of the male is sharp and continuous, and is produced by the friction of the elytra. The genus is extensive, and occurs in many countries. They are usually of a brilliant green. One of the best known in Europe (it is also an English species) is the *L. viridissima*, Lat. (Plate CCXXVIII. fig. 12). It is about two inches in length, of a fine green colour, without spots. The ovipositor is straight, and of the length of the body. Another species (*L. verrucivora*, Fab.) is likewise green, but the elytra are spotted with brown and black. The ovipositor exceeds the length of the abdomen, and is slightly arched. This latter bites pretty severely, and derives its specific name from a practice said to be followed by the Swedes, who allow it to gnaw their warts, which are alleged speedily to disappear, from the action of a black and bilious liquid which escapes from the mouth of the insect during mastication.

Several species are nearly apterous, or present merely scale-like rudiments of the organs of flight, such as the *L. ephippiger*, which now forms a genus under its specific name. Some have the antennæ bearded beneath, with the oviduct shaped like a boat, and form the genus SCAPHURA of Kirby.[6]

All the preceding genera of the leaping or saltatorial Orthoptera have this character in common, that the males effect their peculiar cry chiefly by a portion of the elytra, which is discoloured, transparent, and somewhat resembles a mirror or small tambourine. But in the following genera, the stridulation of the male is effected by the friction of the spiny legs against the sides and edges of the elytra and wings. The antennæ are sometimes filiform and cylindrical, sometimes sword-shaped, or terminated by a mass, always at least as long as the head and thorax. The ligula in the greater number has only two divisions. There are three simple eyes, the labium is notched, the mandibles much toothed, the abdomen conical and laterally compressed. The tarsi are composed of three articulations, and the female is not furnished with a prolonged ovipositor. They all leap better than the preceding genera, and have a higher and more sustained flight. They feed on vegetables, and are extremely voracious. They compose the old genus *Acrydium* of Geoffroy, which Latreille divides as follows.

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Mouth exposed, ligula bifid, a membranous cushion between the hooks, at the end of the tarsi. GENUS PNEUMORA. Antennæ filiform, of sixteen articulations, inserted close upon the inner margin of the eye. Posterior legs shorter than the body, and less adapted for leaping. Abdomen large, vesicular, and appearing as if empty.

We know little of the manners of the insects of this genus (Plate CCXXVIII. fig. 14). They inhabit southern Africa, and feed on vegetable substances. The *P. sexguttata* has green elytra, with three silvery spots on each. It is a very beautiful insect.

GENUS PROSCOPIA, Klug. Without wings. Body long and cylindrical. Head prolonged anteriorly into a point or cone, bearing two short filiform antennæ, composed at most of seven articulations, of which the last is pointed. Posterior legs large and long, approximated to the intermediate, which are farther than usual from the anterior pair.

These singular insects are peculiar to South America, and are usually of a large size. Klug, in his monograph of the genus, has described fifteen species.[7]

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[1] From *gryllus*, a cricket, and *talpa*, a mole.

[2] For a curious account of the habits of the mole-cricket, see *Nouv. Cours d'Agriculture*, deux ed. t. v. p. 163. Its anatomy is described in *Ann. du Mus. d'Hist. Nat.* t. xx. p. 213.

[3] From τρυδακτυλος, *with three fingers*.

[4] *Memorie Scientifiche di Paolo Savi*, Pisa, 1828.

[5] *Règne Animal*, t. v. p. 183.

[6] See also *Règne Animal*, t. v. p. 184; Charpentier's *Horæ Ent.*; and Thunberg in the *Mém. de l'Acad. Imper. de Petersbourg*.

[7] See *Proscopia, Novum genus Insectorum Orthopterorum*, in folio, with two plates.

Orthoptera.

GENUS TRUXALIS, Fab. Head pyramidal, bearing on its extremity, and above the eyes, two prismatic, compressed, ensiform antennæ.

We are acquainted with about a dozen species of this genus. Their distinctive characters have not yet been well expressed, and it is not improbable that several have been confounded. They are characteristic of the warmer countries of the ancient continent. The best known is the *T. nasutus* of Fab. figured by Roesel, *Insect.* ii. Gryll. iv. 1, 2. See also Drury, ii. xl. 1. It occurs in Africa and the south of Europe (Plate CCXXVIII. fig. 10).

GENUS ACRYDIUM. Head ovoid. Antennæ filiform, or terminated by a button, and inserted between the eyes, at some distance from their inner margin. Body solid, and not vesicular. Hinder legs longer than the body.

This genus contains the noted insects commonly called *locusts*, the structure and history of which we shall briefly detail. The head is largely developed, and supports two rather short antennæ, composed of twenty articulations. The true eyes are oval, projecting, and situated on the sides of the head, while the stemmatic eyes, three in number, form a triangle on its summit. The mouth is composed of a large and broad upper lip, slightly notched on its anterior margin; of strong cutting mandibles, irregularly toothed; of maxillæ terminated by three teeth, and supporting at the same time the galeæ by which they are covered, and a pair of filiform palpi, consisting of five articulations; of an inferior lip, broad, advanced, bifid at the extremity, and giving insertion to a pair of filiform palpi of four articulations. The prothorax, of the same breadth as the body, sometimes exhibits superiorly small *keels*, which are prolonged transversely on the sides in slight impressions, appearing to indicate the natural divisions of that portion of the thorax. The chest of the mesothorax and metathorax, or rather the sternum, is broad, flattened, and very dissimilar to that of *Locusta* (Sauterelles), in which it has the appearance of two triangular foliaceous plates. The elytra are coriaceous, narrow, and as long as the wings, which are large, reticulated, folded like a fan, and frequently ornamented by brilliant shades of red or blue. The legs are of unequal length,—the two anterior pair being of ordinary proportions, while the hindmost are large, and formed for leaping. Many species exhibit on each side, and near the origin of the abdomen, a large cavity, closed interiorly by a thin membranous diaphragm, of a pearly white colour. Latreille regards it as a pneumatic pouch, forming an acoustic instrument. It may no doubt be influential in regulating the sounds uttered by these insects, which, however, are certainly produced in the first place by the alternate friction of the inner face of the hind legs against the surface of the elytra.

The females, which are not provided with an exserted ovipositor, lay their eggs in some instances in the ground, in others on the stalks of plants, to which they adhere naturally by a gummy secretion, and are, moreover, enveloped and protected by a frothy matter, which hardens over them. The larvæ, the nymphæ, and the perfect insects, are all voracious, and feed on plants. The ravages of locusts are so well known to all readers of foreign travels, and accounts of their desolating inroads have been so frequently extracted, and published in numerous popular works, that a few slight notices of the subject will here suffice.

Locusts are of very common occurrence in many parts of Africa. Mr Barrow records, that in the southern districts which he visited, the surface of an area of nearly 2000 square miles might literally be said to be covered by them. The water of a wide river was scarcely visible, in consequence of the innumerable dead locusts which floated on its surface, apparently drowned in their attempts to reach the reeds which grew along its shores. Except these much wished-for reeds, they had devoured every other green thing. Their destruction on a former occasion was sudden and singular. All the full-grown insects were driven into the sea by a tempestuous wind, and were afterwards cast upon the beach, where they formed a bank three or four feet high, and extending *nearly fifty English miles.* The smell, as may be easily supposed, was most abominable, and was sensibly felt at the distance of 150 miles. In regard to the Indian locusts, a correspondent of Messrs Kirby and Spence informed these authors, that he was an eye-witness to an immense army of locusts which ravaged the Mahratta country, and was supposed to come all the way from Arabia. This column extended *five hundred miles*, and was so compact when its members were upon the wing, as to darken the sun like an eclipse, so that no shadow was cast upon the ground, and some lofty tombs, distant not more than two hundred yards from the observer, were rendered invisible. These were not the *Gryllus migratorius* of Linnæus (*A. migratorium*, Plate CCXXVIII. fig. 13), but a red species, the peculiar colour of which is said to have added additional horror to the scene;—for after having stript the trees of their foliage, they congregated around the bare and desolate branches, producing a hue like blood. When they moved again, "the sound of their wings was as the sound of chariots, and of many horses running to battle."

The migratory flight of these insects, their desolating effects upon vegetation, and consequent injury both to man and beast, have afforded a frequent subject of exercise to the pen of the poet; but by none has their injurious inroads been so magnificently portrayed as by the prophet Joel. "A day of darkness and of gloominess, a day of clouds and of thick darkness, as the morning spread upon the mountains; a great people and a strong: there hath not been ever the like, neither shall be any more after it, even to the years of many generations. A fire devoureth before them, and behind them a flame burneth: the land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them. The appearance of them is as the appearance of horses; and as horsemen so shall they run. Like the noise of chariots on the tops of mountains shall they leap, like the noise of a flame of fire that devoureth the stubble, as a strong people set in battle array." "The earth shall quake before them; the heavens shall tremble: the sun and the moon shall be dark, and the stars shall withdraw their shining." "How do the beasts groan! the herds of cattle are perplexed because they have no pasture; yea, the flocks of sheep are made desolate."

Dr Southey, "the laurel-honouring laureate," as he is well called by his friend and fellow poet S. T. Coleridge, has also, in his "wild and wondrous lay" of Thalaba, sketched the progress of these destroyers.

> Onward they came, a dark continuous cloud
> Of congregated myriads numberless,
> The rushing of whose wings was as the sound
> Of a broad river headlong in its course
> Plunged from a mountain summit, or the roar
> Of a wild ocean in the autumn storm,
> Shattering its billows on a shore of rocks.

The scene of the above quotation is Arabia, where these insects are very formidable, and of different kinds. Forskal thinks that the species which chiefly infests that tented region, and which he names *Gryllus gregarius*, is distinct from the *Gryllus migratorius* of Linnæus. They come invariably from the east, which induces the Arabs to believe that they are produced by the waters of the Persian Gulf. Nejed is particularly exposed to their ravages; and no sooner have they destroyed the harvests, than they penetrate by thousands into the dwelling-houses, devouring whatever they can find, even to the leather of the water vessels. They appear in the air at a distance like clouds of smoke; and their near approach, accompanied as by a sound of falling water, stuns the inhabitants with astonishment and dread. They alight upon a field, and its verdure disappears,—the lofty palms are stript of their long shadow-casting leaves,—and pulse and all other succulent crops are voraciously devoured. Grain, however, if ripe, usually escapes, in consequence of its hardness and aridity. The Bedouins of Sinai are frequently driven to despair by the multitudes of these flying vermin, which remain for a period of a month or six weeks before they finally disappear. The time of their arrival is towards the end of the month of May, when the Pleiades are setting,—a coincidence which leads the natives to imagine that locusts entertain a dread of that beautiful constellation. Although a few are visible every year, the great flights are inflicted only every fourth or fifth season. Most of the Arabs, except those of Sinai, are in the habit of eating these insects. "In almost every town there are shops where they are sold by measure. In preparing them, the cook throws them alive into boiling water with which a good deal of salt has been mixed. After a few minutes they are taken out and dried in the sun; the head, feet, and wings are then torn off; the bodies are cleansed from the salt, and perfectly dried, after which they are put up into sacks or bags. Sometimes they are broiled in butter, and spread on the unleavened bread used at breakfast. The Jewish Arabs believe that the food of which the Israelites ate so abundantly in the desert was showers of locusts."[1] They are also used as food in several African countries, and are even exported as articles of commerce. The elytra and wings are first cut off, and then the bodies are preserved in brine. M. Miot, in his translation of Herodotus, has observed that the numerous carcasses of *winged serpents* said to have been noticed in Egypt by the early Greek historian, were in all probability masses of the dead bodies of some large species of locust. Latreille coincides in this opinion.[2]

The most noted species is that already mentioned under the name of *Acrydium migratorium* (*Gryllus migratorius*, Linn.), Plate CCXXVIII. fig. 13. It measures above two inches and a half in length. Its usual colour is green, obscurely spotted, the elytra pale brown, marked with black. The mandibles are likewise black, and the thorax is marked by a slightly elevated crest. This species is common in Poland, but occasionally extends its ravages into other European countries. It was very destructive in Provence so lately as the year 1819. It is well known in the Levant, in Barbary, and Egypt. These countries produce another species, likewise found in the south of France, the *A. lineola*, Lat. It is of a reddish-brown colour. The crest of the thorax is intersected by three impressed transverse lines; there is a conical pectoral point between the anterior legs, almost as long as the haunches; and the posterior legs are furnished with reddish spines, black at their extremity. This species is eaten in Barbary. Another kind, native to Senegal and other parts of Africa, of a yellow colour, spotted with black (it is figured by both Shaw and Denon, in their Travels), is ground when dry into powder, and used as flour. Many large exotic species are characterized by the superior portion of the thorax being greatly elevated, much compressed, and forming a sharp crest, rounded and prolonged backwards to a point. Of this kind, though of smaller dimensions, is the *A. armatum*, found in the south of Europe, and figured by Fischer.[3] Others have the elytra and wings so abbreviated, at least in one of the sexes, as to be incapable of flight. These form the generic group named PODISMA by Latreille. Such as exhibit a swelling or button-like expansion at the tips of the antennæ form the genus GOMPHOCERUS of Thunberg;—for example, the *A. sibiricum* (figured by Panzer, *Fauna Insect. Germ.* xxiii. 20), which occurs alike among the desert steppes of Siberia and the mountain passes of St Gothard.

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In this second section of the ACRYDIUM of Geoffroy, a part of the under portion of the head is received into a cavity of the præsternum. The ligula is quadrifid, and the tarsi are unprovided with a cushion between the claws. The articulations of the antennæ do not exceed from thirteen to fourteen. The thorax is prolonged backwards in the form of a large scutellum, sometimes exceeding the body in length. The elytra are extremely small. Such are the characters of the genus TETRIX of Latreille (Plate CCXXVIII. fig. 15), which is composed of a considerable number of small species. A good light has been thrown on their characters and classification by MM. Lepelletier and Serville, in the *Encyclopedie Méthodique*, article *Tetrix*, as well as in the more recent works of Mr Zetterstedt.[4] The genus contains the little chirping insects so frequent in this country on dry and sunny banks, and known under the familiar name of *Grasshoppers*.

ORDER III.—HEMIPTERA.[5]

The insects of this order have neither mandibles nor maxillæ properly so called. Their mouth is fitted for suction, and is composed of a tubular articulated rostrum, cylindrical or conical, curved inferiorly, or directing itself along the breast, and, when extended, presenting the appearance along its upper surface of an elongated groove or canal, in which are lodged three delicate pointed bristles, covered at their base by a ligula. These bristles form by their union a needle-like sucker, of which the tubular piece just mentioned forms the sheath, in which they are retained by means of the ligula or triangular basal portion. The inferior bristle is in fact composed of two, which unite together not far from their origin, so that the sucker itself consists of four pieces. Savigny is of opinion that the two superior bristles are analogous to the mandibles, and that the inferior represent the maxillæ[6] of the masticating orders. According to this view, which the author has illustrated with admirable assiduity and skill, the mouth of hemipterous insects is as usual composed of six principal portions, the so-called ligula representing the labrum, and the articulated sheath the labium, of the other orders.[7] According to Latreille, the languette properly so called also exists, and under a form analogous to that of the supposed labrum, but bifid at the extremity. The palpi, however, have entirely disappeared, with the exception of some slight vestiges of those parts observable in the genus *Thrips*. These representative relations between the parts of the mouth in the mandibulated and haustellated orders had in fact been sus-

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[1] *Edinburgh Cabinet Library*, vol. xiv. (Arabia, vol. ii.) p. 460.

[2] *Règne Animal*, v. 187.

[3] *Entom. de la Russ.* i. Orthopt. i. 1.

[4] *Orthoptera Succiæ*, 1 vol. 8vo, Lund. 1821, and *Fauna Laponica*, 1 vol. 8vo, Hamm. 1828.

[5] RYNGOTA, Fab.

[6] *Mém. sur les Animaux sans Verteb.* i. part i.

[7] See Plate CCXX. figs. 4 and 6, and the detailed explanation of the same at page 69 (*note* 1) of this article.

Hemiptera Heteroptera.

pected by Latreille previous to their laborious demonstration by the ingenious Savigny.[1]

The elytra of a great portion of the hemipterous order are of a coriaceous texture throughout their principal extent, with their terminations membranous. They thus partake of the nature of both elytra and wings, and the order, as formerly mentioned, derives its name from that peculiarity. Among the Cicadæ and the Aphides, however, all the four wings are membranous, and frequently quite clear and transparent. In *Tettigonia*, *Membracis*, *Flatta*, &c. they are of a denser consistence; while in *Aleyrodes* they are farinaceous, and of a milky translucence. Certain kinds are apterous, as the bed-bug, some species of *Lygæus*, and the females of the cochineal insect,—but these anomalies do not remove them from the hemipterous order, to which the structure of the mouth shows them to belong.

The composition of the thorax in these insects begins to experience some modifications, which exhibit their relation to the ensuing orders. The first segment, or prothorax, in certain cases resembles in extent that of the Coleoptera; but in others it is much more minute, and becomes incorporated with the second segment, which is then manifest or exposed. The scutellum is sometimes extremely small, or altogether imperceptible; while in certain genera, such as *Scutellera* and *Membracis*, it is greatly dilated, and covers the entire upper surface of the body, concealing the elytra and wings.

The sucker, regarded as a sting, and so named by the ancient naturalists, is adapted only for the extraction of animal or vegetable matter in a fluid state. The delicate parts of which it is composed penetrate various organic substances, the nutritive juices of which are forced to flow into the interior canal by successive compressions, till they reach the œsophagus.

The antennæ of the hemipterous tribes are frequently very small, and of difficult detection. In *Psylla*, *Cimex*, *Thrips*, and others, they are very obvious; in *Cicada* they are short, simple, setaceous threads; in *Fulgora* they are still shorter and subulated; while in *Nepa*, *Ranatra*, &c. they are placed beneath the eyes, and so abbreviated as to be rendered visible only by reversing the insect.

The eyes are rather large, and between them, on the upper part of the head, in many species, there are two or three of the stemmatic kind, or ocelli, called *yeux lisses* by the French entomologists.

The nature and amount of the tarsal articulations differ according to the genera or tribes; but the greater number of hemipterous insects are characterized by three divisions of the tarsi. In some the anterior tarsi are composed of only a single piece, which is bent upon the leg in the form of a pincer; while in the aquatic genera, such as *Naucoris* and *Notonecta*, the posterior legs are oar-shaped, with the tarsi composed of two articulations.

All hemipterous insects pass as usual through three stages of mutation. But their metamorphosis is not in any case complete, and their changes consist rather in the development of the organs of flight, and the increased bulk of the body, than in any very decided or obvious transformation. Their anatomical structure exhibits a stomach with a rather solid and muscular coat, a small intestine of medium length, succeeded by a large intestine, divided into various swellings, and of a small number of biliary vessels, inserted at some distance from the pylorus.[2] The habits of the order are extremely various, as we shall show when we come to treat of the genera more in detail.

HETEROPTERA.[3]

Sucker originating from the front of the head. Elytra membranaceous at their extremity. First segment of the thorax much larger than the others. Wings horizontal or slightly inclined.

FAMILY I.—GEOCORISÆ.[4]

Antennæ exposed, longer than the head, and inserted between the eyes near their internal margin. The tarsi are composed of three articulations, of which the first is sometimes extremely short. These insects form the great genus CIMEX of Linnæus, which has now undergone many modifications. They are principally *terrestrial* insects, although some dwell upon the *surface* of waters. From several of the species a disagreeable odour emanates.

GENUS SCUTELLERA,[5] Lam. Sheath of the sucker of four distinct articulations. Labrum prolonged beyond the head, awl-shaped, and striated above. Tarsi with three articulations, the first as long or longer than the third. Antennæ filiform, of five articulations. Body usually short, oval, or rounded. Scutellum covering the abdomen. (Plate CCXXIX. fig. 1.)

The insects of this genus, formed by Lamarck from *Pentatoma* of Olivier, live on plants, of which they absorb the juices by inserting their suckers in the leaves or tender twigs. They occur in many countries, but are larger and more brilliant in equatorial than temperate regions. The *S. nobilis* of Latr. is of an elongated oval form, and of a metallic or golden blue colour, spotted with black. It is found in Asia. The *S. stokerus* is oval, green, spotted with black, and has a red abdomen. It occurs in the Antilles. Of the European species we shall mention only the *S. lineata* (*Cimex lineatus*, Linn.), which is about four lines in length, red, radiated above with black lines, and marked beneath with black spots linearly disposed. It is common in Central and Southern Europe on umbelliferous flowers.[6]

GENUS PENTATOMA,[7] Oliv. Elytra exposed. Scutellum covering only a portion of the body. Other characters as in the preceding genus.

The species of this genus, known as *wood-bugs*, and under other names, are extremely numerous. They occur in every region of the world, and under various temperatures. The species proper to the warmer countries of Africa, America, and the East Indies, attain to a considerable size, and are adorned by brilliant colours. The larvæ of these insects do not greatly differ from the perfect state, except in having neither wings nor elytra. The nymphæ possess these organs in a rudimentary state, inclosed in sheaths. Their changes of condition are accompanied by a general casting of the skin. In their various states they exist on vegetable juices, which they seem as it were to pump up by means of their suckers. Some species, however, have been seen to attack insects, even those of their own kind, and suck their softer parts. Almost all of them exhale a disagreeable and penetrating odour,

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[1] *Hist. Nat. des Crust. et des Insect.* t. ii. p. 140–143.

[2] *Règne Animal*, v. 192.

[3] From ἑτεροιος, *of a different kind or nature*, and πτερα, *wings*.

[4] From γη, *the earth*, and κορις, *bug*.

[5] From *scutellum*, a shield.

[6] Consult, for the other species, Fabricius, *Systema Ryngotorum*, genus *Tetyra*.

[7] From πεντα, *five*, and τομα, *division*.

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which adheres to whatever substance the insect touches. The eggs are deposited on the stalks of plants, regularly disposed, and made to adhere by means of a remarkably tenacious liquid. They are not unfrequently adorned by extremely agreeable colours.

A pleasant and curious narrative is given by Degeer, relating to the female of a species of this genus, the *Cimex griseus* of Linn. He found on a birch tree several of these females, each followed by a little troop of thirty or forty young ones, which accompanied their mother as chickens do a hen. The parents seemed to watch over them with the greatest solicitude. This is a singular fact in the history of insects, which for the most part are not personally regardful of the welfare of their offspring, although they seldom fail instinctively to deposit their eggs in situations the best adapted for the sustenance and preservation of the future larvæ. Several of the generic groups proposed by Fabricius, as derivable from the genus Pentatoma of Olivier, are not adopted by Latreille; while, on the other hand, several genera proposed by more recent writers have been adopted.[1]

GENUS TESSERATOMA, Pel. et Serv Antennæ with four articulations. Body very flat, membranous, with the margins much dilated, notched, and angular. Thorax prolonged posteriorly in the form of a truncated lobe. This genus was formed upon the *Edessa papillosa* and *amethystina* of Fabricius. The species are chiefly from India and the Eastern Islands (Plate CCXXIX. fig. 2). Certain species from Brazil, and we believe other countries, likewise very flat, with the margins notched and dilated, with the anterior extremity of the body forming a clypeus truncated in front, and cloven at the sides, form the genus PHLÆA of the *Encyc. Méth.* (Plate CCXXIX. fig. 3).

GENUS COREUS,[2] Fab. Antennæ with four articulations, filiform, or larger at the extremity, the last being usually shorter than the preceding. Body oval. Sheath, labrum, and tarsi similar to those parts in the genus Pentatoma, which they resemble in their habits of life.

The species of this genus have the head in general of a trigonal form, and sunk, without apparent neck, into the prothorax, which is narrow anteriorly, and broader behind. The eyes are small, but prominent. The scutellum is triangular and obvious. The elytra equal the length of the abdomen, which is depressed, with elevated edges. The legs are long and slender. These creatures are said by some authors to feed on other insects, as well as on the juices of plants. The *C. marginatus* is of an obscure brown, with two small advanced points between the antennæ. The latter have their second and third articulations fulvous. It exhales a strong smell of apples. Wolff, *Icon. Cimic.* fascic. i. p. 20, t. 3, fig. 20. The *C. hystrix* is an insect of a very bizarre appearance, found in France and elsewhere. Sparmann collected a species not very dissimilar at the Cape of Good Hope,—of a grey colour tinted in parts with reddish brown; spiny, membranous, the edges of the thorax relieved in roundish lobes. The abdomen likewise margined by numerous brown-coloured lobes. The second and third joints of the antennæ are spiny at the extremity. It was named *C. paradoxus* by Fabricius (Plate CCXXIX. fig. 4). Between the principal genus *Coreus*, Fab. and that named *Lygæus* by the same author, as now restricted, several intermediate ones occur in the system of Latreille.[3] Of these, however, we shall mention merely the genus *Neides* (Plate CCXXIX. fig. 5), distinguished by its greatly elongated and almost linear form of body, and slender limbs and antennæ.

GENUS LYGÆUS, Fab. Antennæ terminated by an elongated article, almost cylindrical, and of the same thickness as the preceding joint. The stemmatic approach the true eyes, and the membranous appendages of the elytra frequently offer only four or five nervures.

The *L. equestris* (Plate CCXXIX. fig. 6) is red, spotted with black. The thorax is black before and behind, and there are two points of the same colour on the scutellum. The elytra are traversed by a black band, and there are two small spots and a point of white upon their membranous portion. It measures about five lines in length. The abdomen has four ranges of points. The *C. apterus* (Stoll, *Cimic.* ii. xv. 103) is rather less, red, and without wings. The head, a spot on the centre of the thorax, and a large point on each elytron, are black. The extremities of the elytra are truncated, or without membranous appendages. It sometimes occurs winged. The species with the large anterior thighs have been formed into a separate genus by MM. Lepelletier and Serville. Those with angulated antennæ form the genus NEIDES of Latr. already mentioned, and the genus ALYDUS of Fab. includes such as have filiform antennæ without dilatation, and the body narrow and elongated.[4]

All the preceding genera of the Linnæan CIMICES agree in having four articulations to the sheath of the sucker, and a prolonged and striated labrum; but those which follow have only two or three apparent articulations to the sheath, and the labrum is short and without striæ. The first joint of the tarsi, and frequently the second also, are very short in the greater number.

a.

Feet inserted in the middle of the chest, and terminated by two distinct hooks, which take their origin from the central extremity of the tarsus. They are not adapted for rowing, or running on the surface of the water.

*

Rostrum straight, more or less inclosed in a sheath Eyes of ordinary dimensions. Union of the head and thorax not characterized by a narrow neck, or sudden restriction. The body is usually membranous in whole or in part, and is generally extremely flat. This group of genera composes the major part of the primitive genus ACANTHIA of Fabricius, which the author himself afterwards dismembered.

GENUS SYRTIS, Fab. Anterior feet formed of a monodactyle claw like that of the Crustacea, and serving them in like manner to seize their prey. Antennæ terminated by an oval mass or enlarged articulation, and lodged in a groove of the head and thorax.

The species of this genus feed on flies and other insects, which they seize with their fore legs, after the manner of the *Mantides*. They live in woods. The *S. crassipes* (Wolf, *Icon. Cimic.* tab. 9, fig. 82) measures about three lines and a half in length. The head and thorax are brownish red; the abdomen of a deeper hue as far as the centre,—the sides and towards the base being paler. The antennæ, under parts of the body, and feet, are reddish yellow. This is a European species. Most of the others occur in South America.

GENUS TINGIS, Fab. Body extremely flat. Antennæ with the third articulation much longer than the others, and terminated by a button.

These insects live on plants, of which they pierce the leaves and flowers, not unfrequently producing great injury to their vegetation. The species found on the peartree, and known to the continental horticulturists under the name of *tiger*, is extremely destructive. It is the *T. pyri* of Lat. and is distinguished by a white reticulated thorax, the edges raised, and inflated in the centre. The scutellum is foliaceous. The elytra are white, with two black bands. The larva of *T. clavicornis* inhabits the flowers of *Teucrium Chamædrys*, and, by piercing the petals, causes them to thicken,—thus preventing their healthy development. The puncturings of the perfect insects of this genus sometimes produce a kind of gallnut.

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[1] See *Règne Animal*, t. v. p. 193-4.

[2] From κορις, *bug.*

[3] See *Règne Animal*; *Encyc. Méthod.* t. x.; and the *Systema Ryngotorum* of Fab.

[4] *Ibid.* and *Genera Crustac. et Insect.* iii. p. 126.

GENUS ARADUS, Fab. Body formed like that of Tingis; but the antennæ are cylindrical, with the second articulation almost as long or even longer than the third.

These insects occur chiefly on the trunks and beneath the bark of trees, where they congregate during the winter. They show themselves more actively in spring. The *A. corticalis* of Wolff (*Cimic.* fasc. iii. t. ix. fig. 81) serves as a type of the genus.

GENUS CIMEX, Lat. Resembles the preceding genera in the form of the body; but the antennæ are almost setaceous, composed of four articulations, of which the first is shorter than the others, the second thick and long, the third also lengthened and more slender than the others, the last scarcely increasing in thickness at the extremity. Elytra extremely small. No true wings.

Of this genus the *C. lectularius* or bed-bug (Plate CCXXIX. fig. 7) is probably too well known in many quarters to require particular description. It deposits its eggs in the month of May. The larvæ differ from the perfect insects in wanting the elytra. This species, though mentioned by Dioscorides, is said to be not an original inhabitant of Europe. It is also believed to have been unknown in London prior to the great fire in 1666, after which calamity it was transported thither in timber from America. It is said sometimes to acquire wings, and infest young pigeons, swallows, and other birds. Latreille however is of opinion that the kind attached to the last-named birds is of a distinct species from that which troubles the lords of the creation. The best means of extirpating bugs are care and cleanliness.

* *

Rostrum exposed, arched, sometimes straight, but with the labrum projecting. The head suddenly restricted behind, so as to form a neck-like portion.

†

Eyes not remarkably large. Neck apparent.

GENUS REDUVIUS, Fab. Rostrum short, but sharp and piercing. Thorax distinctly lobed. Elytra at least as long as the abdomen. Tarsi triarticulated. Antennæ with four articulations, setaceous, and extremely slender at the extremities.[1]

The species which form this genus are predaceous, and greedily attack other insects, sucking out their juices with their sharp-pointed beaks. The *R. personatus* is about eight lines in length, and of a blackish-brown colour, without spots. It is common in France. This species, which inhabits the interior of houses, covers itself with ordure, or the sweepings of apartments, and, thus disguised, lies in wait in some obscure corner for its prey. No sooner does a fly or other feeble insect approach within a calculated distance, than it suddenly darts upon it, and sucks it to death. Sometimes it may be seen approaching its victim by slow and cautious steps, till the fly, thrown off its guard by this insidious show of peace, is instantaneously captured by one deadly spring. Its bite is so severe as to produce the immediate death of its captive; and indeed we are informed that our venerated friend Latreille having been bitten on the shoulder by a Reduvius, experienced a great swelling of the entire arm, and suffered severe pain for several hours. It is chiefly in the larva and nympha states that these insects disguise themselves in the manner just mentioned. Entomologists are acquainted with a great many species of this genus, few of which, however, are native to Europe. The rest are spread over Asia, Africa, and America.

We shall here briefly notice a few of the genera which in recent times have been formed by dismemberment of the genus Reduvius as originally constituted by Fabricius. In the genus HELOPTILUS of Lepel. et Serv. the antennæ have only three articulations, of which the last two are garnished with long hairs, disposed in two rows, and verticillated on the terminal joint. In the genus PETALOCHEIRUS of Palisot de Beauvois,[2] the two anterior legs are singularly expanded into oval plates or shield-like dilatations. These insects are of African origin. The *P. rubiginosus* is blackish-brown, with the antennæ and feet of a rust colour. The thorax is spiny on either side, and surrounded by a line of yellow. The scutellum is surmounted by a straight spine. The only other species with which we are acquainted is the *P. variegatus* of the author last named. In the genus ZELUS the form of the body is linear, and the legs very long, slender, and similar to each other. The genus PLOIARIA is characterized by the same linear body, and the like length and tenuity of limb; but the two anterior legs have the haunch elongated, and formed, as in Mantis, for the seizure of their prey.

† †

Eyes remarkably large. No apparent neck.

The insects of this subdivision run swiftly along the margin of waters, making occasionally little leaps.

GENUS LEPTOPUS, Lat. Rostrum short, arched, and spiny beneath. Antennæ setaceous. Anterior thighs large and spiny.

This genus was established by Latreille upon *L. littoralis*, a small insect about two lines in length, of an obscure ash colour, with some spots upon the elytra, and the margins of these parts whitish. Their membranous appendages are pale, with obscure nervures. The feet are pale yellow. This species was discovered in Spain by Leon Dufour; and another nearly allied to it, *L. lapidicola*, has been taken by Basoches in the department of Calvados.

GENUS ACANTHIA, Lat. Rostrum long, straight, with the labrum projecting beyond the sheath. Antennæ filiform, or slightly enlarged towards the extremity. Form of the body oval.

This genus is composed of insects belonging to the genus *Salda* of Fabricius, such as S. *striata*, *zosteræ*, *littoralis*, &c. We may regard as its type the *Lygæus saltatorius* of Fab., a species which dwells by the banks of rivers, and runs and leaps with agility. Certain species, of which the antennæ are much shorter than usual, and bent over the eyes, the body shorter and more rounded, with the scutellum rather large, form the genus PELOGONUS of Latreille. These Hemiptera approach those of the genus *Naucoris* in their nature, and seem to conduct towards them in common with the following.

b.

Four posterior feet slender and long, inserted on the sides of the chest, and distant from each other at their points of articulation. The hooks of the tarsi are very small, indistinct, and placed in a fissure of the lateral ex-

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[1] The first joint is often united to the second, and that to the third, by means of a very small article or rotule. (*Regne Animal*, v. 202.)

[2] *Insectes recueill. en Afr. et en Amer.* fasc. i.

Hemiptera Heteroptera.

tremity of the tarsus. The feet are adapted for rowing or walking on the water. These characters are proper to the genus *Hydrometra* of Fabricius, which Latreille has divided into three, as follows.

Genus Hydrometra,[1] Lat. Antennæ setaceous. Head prolonged into a muzzle, and receiving the rostrum, of which the articulations are by no means obvious, in an inferior groove.

These insects dwell in moist places, and run upon the surface of waters. (Plate CCXXIX. fig. 8.) Their bodies are narrow, thin, linear. Their eyes are large and globular, and are placed towards the centre of the lateral parts of the muzzle, or rather muzzle-shaped head. The best known species is *H. stagnorum*, which measures about five lines in length. It is of a black or blackish-brown colour, with the feet of a redder hue. The elytra are very short, with two nervures on each. This species is common throughout Europe. The *H. fossarum* of Fab. is a native of the East Indies. We are inclined to regard it as belonging to the next genus.

Genus Gerris, Lat. Antennæ filiform. Rostrum with three articulations. Anterior feet serving the office of pincers. Second pair distant from the anterior, and as long again as the body. (Plate CCXXIX. fig. 9.)

These insects have elongated bodies, are usually of a blackish colour, and are met with on the surface of still waters, on which they advance as it were by starts. Their under surface seems covered by a peculiar coating, of a black or silvery hue, according to the position in which the insect is held, and which probably protects it from the influence of the subjacent liquid. They appear rather to row than to walk upon the surface. The species are insectivorous, and prey upon such of their own class as they can master, and especially upon any land species that have fallen accidentally into the water, and are naturally inactive in that element. These they immediately seize upon with their anterior feet. The *G. lacustris*, Lat. (*Hydrometra lacustris*, Fab.), figured on the plate above referred to, is of a blackish-brown colour, greenish above. The feet are brown. The body is terminated by a projection. This species presents some peculiarities worthy of notice. There are two varieties of it, one of which is winged, the other apterous. The former of these constitute the *punaises aquatiques très-allongées ailées* of Degeer, the latter correspond to the *punaises aquatiques très-allongées non ailées* of that author.[2] Such as make their appearance in spring, and which have without doubt passed the winter beneath the ice, or under cover of the frozen banks, are all apterous, but resemble perfect insects in every other part of their structure. Sexual intercourse takes place among them. It was this latter circumstance which induced Geoffroy to believe that they offered a remarkable exception to a general rule, and that fecundation took place in the state of nymph or larva. Degeer, in combating this opinion, maintained that these apterous insects were of a distinct kind, and perfect in their way. M. Audouin, on the other hand, is of opinion that they may be regarded as individuals of the ordinary kind, proceeding from larvæ of the preceding year, of which the development has been checked by the rigours of the winter season, and the consequent condition of torpidity. He conceives that the wings are not, in these aquatic insects, organs of the first importance, and that the influence of surrounding causes is on that account the more likely to prove effectual, and that thus they remain rudimentary, when the other parts of the body, and the generative system in particular, have attained the maximum of their development. He illustrates this point by reference to the genera *Lampyris* and *Drilus*, in which (in the females) the organs of flight of the perfect insects are scarcely if at all more developed than in the larva state, while all the interior parts of structure are fully and functionally completed. The apterous individuals, then, of *G. lacustris*, which are observed to fulfil the offices of the perfect insect, are larvæ only so far as regards the undeveloped condition of the wings.[3]

General Hardwicke has described a new species of this genus from Nepaul, under the name of *G. laticaudata*. The extremity of the abdomen is remarkable for certain processes like teeth or claws.[4]

Genus Velia. Antennæ filiform, as in Gerris; but the rostrum has only two apparent articulations, the legs are much shorter than in that genus, and are inserted at nearly equal distances from each other.

Like the preceding species, these insects live on the surface of water. Their motion, however, is more like running than swimming. The *V. currens* is blackish-brown, with the superior edges of the abdomen fulvous, spotted with black. The *V. rivulorum* is black spotted with white, the abdomen fulvous.

FAMILY II.—HYDROCORISÆ.[5]

Antennæ inserted and concealed beneath the eyes, shorter than the head, or not exceeding it in length. Tarsi composed of only two articulations. Eyes for the most part remarkably large. These Hemiptera are aquatic and carnivorous. They prick severely with their rostrum, and seize upon other insects with their anterior feet, the joints of which are bent upon themselves, so as to form a kind of pincer. Their heads appear as if sunk into or intimately united to the thorax. The rostrum is short. Their metamorphoses do not differ from those of the other Hemiptera.

Tribe 1st, Nepides.

We here place the species of the unrestricted genus Nepa of Linnæus, commonly called *water scorpions.* They have the anterior legs in the form of hooks or nippers,—composed of a thigh, sometimes large, sometimes elongated, with a groove on its under surface for the reception of the tibia, and of an extremely short tarsus, which forms as it were a hook or crotchet with the tibia. The form of the body in some is oval and much depressed, in others it is more linear. Latreille divides this tribe into the following genera.

Genus Galgulus, Lat. All the tarsi similar to each other, cylindrical, with two distinct articulations, of which the terminal is provided with two hooks. The antennæ do not appear to have more than three articulations, of which the last is the largest, and of an ovoid form.

The only species of this genus with which we are acquainted, *G. oculatus*, Lat. (*Hist. Nat. des Crust. et des Insect.* xii. 286, pl. 95, fig. 9) was placed by Fabricius in the genus *Naucoris*. It is of a dull ashy brown, with some paler spots upon the elytra. The thorax is unequal. The legs are pale brown, with deeper spots. This odd-looking insect was brought by Bosc from Carolina. Its body is short and rough. The head has little length, but is pro-

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[1] From ὕδωρ, *water*, and μετρον, *measure.*

[2] *Mem. sur les Insectes*, iii. 311.

[3] *Diction. Class. d'Hist. Nat.* vii. 337.

[4] *Linn. Trans.* xiv. 134, pl. 6.

[5] From ὕδωρ, *water*, and κορις, *bug.*

Hemiptera Heteroptera.

longed laterally into two angles which support the eyes. The prothorax is lobed posteriorly, and placed before a triangular scutellum, on each side of which are inserted the short and coriaceous elytra. The thighs of the anterior legs are swollen and dentated beneath, and the tibiæ and tarsi are applied close to them when the insect is in a state of repose. We are not aware that any thing is known of the habits of this insect, further than that it is aquatic.

Genus Naucoris,[1] Geoff. Labrum exposed, large, triangular, and covering the base of the rostrum. Antennæ simple, and consisting of four articulations. Tarsi of the anterior feet terminating in a simple point or crotchet. The middle and hinder pair of legs ciliated,—their tarsi with two articulations, terminated by a pair of hooks.

Of this genus the body is usually depressed, almost ovoid, with the head rounded anteriorly, and the eyes lengthened and depressed. The abdomen is dentated around its edges. The species are extremely active, and swim with great ease and swiftness, making use of their hinder legs as oars. They sometimes quit one pool of water for another, and they then make good use of their wings. They are extremely voracious, and destroy a great number of other insects. The larvæ and nymphs inhabit the same situations as the perfect insects, and differ from them chiefly in the absence of wings. The nymphs indeed exhibit the rudiments of these organs enclosed in a kind of case, from which they expand at the period of the completed metamorphosis. The *N. cimicoides* (*Nepa cimicoides*, Lin.) measures about six lines in length. It is of a greenish-brown, with the head and thorax paler and spotted. The eyes are blackish. The margins of the abdomen are strongly dentated. It is common throughout the fresh waters of Europe.

Genus Belostoma, Lat. Labrum sheathed. Antennæ semi-pectinated. All the tarsi with two articulations. Abdomen terminated by a pair of setæ.

The *B. grandis* (*Nepa grandis*, Fab.) may be regarded as the type of this genus. It is a very large insect, measuring nearly three inches in length. It is of a greyish colour, spotted with brown. The legs are likewise spotted. The thorax is smooth. It is common in collections of foreign insects.

Genus Nepa.[2] Labrum and setæ as in the preceding genus. Rostrum curved beneath. Anterior tarsi with only one articulation,—the middle and posterior pair with two. Antennæ appearing forked. Haunches of the anterior legs short, and the thighs much broader than the other parts.

The body in this genus is almost elliptical, and narrower and more elongated than in the preceding genera. The head is small, and partly lodged in a notch of the thorax. The setæ, which terminate the abdomen, serve, according to some authors, for the purposes of respiration in the moist and muddy places in which they dwell. The Nepæ, in their various states, inhabit the quiet waters of ponds, lakes, and marshes. They swim more leisurely than many of their congeners, and often proceed along the surface of the mud below, in search of the minute insects of which they make their prey, and which they seize with their anterior feet. Their eggs are of an oval form, and, when examined with a microscope, are seen to be crowned by an aigrette of seven small threads. Swammerdam anatomized these insects, and has given us some curious details regarding the arrangement of the eggs in the ovaries. They are so disposed that the crown-like threads of the one which is next the orifice embraces the one which follows, and so on consecutively. The generative system of the male is singular, and very complicated. The larvæ leave the eggs in midsummer. They differ from the perfect insects chiefly in wanting the wings and setæ. The nymphs acquire, as usual, rudimentary wings inclosed in sheaths, and placed on each side of the body. The perfect insect frequently quits its subaqueous abode during the dewy night, and flies about with great agility. The genus is by no means numerous in species, although these seem pretty extensively distributed over the waters of the earth.

The *N. cinerea*, Lin. (Plate CCXXIX. fig. 10), is nearly an inch in length, of an ash colour, the upper part of the abdomen red, the tail shorter than the body. We owe to M. Leon Dufour some curious and excellent observations on the anatomy of this species, and on that of *Ranatra linearis*.[3] These insects present a peculiar organ, which the French observer regards as a kind of pectoral trachea, communicating with those of the ordinary kind. It forms in *R. linearis* a pair of elegant *panaches*, or feather-like bunches, of a pearly whiteness, composed of numerous little branches, and situated in the centre of the muscular mass of the breast. In *N. cinerea* the pectoral tracheæ appear to offer the vestiges of a pulmonary organ. They consist of two oblong bodies, placed immediately below the region of the scutellum, clothed by a fine membrane, smooth, and white as satin. They are almost as long as the chest, free except at their extremities, and are filled with a substance like tow, which, when examined under the microscope, presents a homogeneous tissue, formed by vascular arbusculæ. The nervous system appears to consist of two large ganglions, the one placed beneath the œsophagus, the other in the chest betwixt the first and second pair of feet, and throwing out two remarkable cords, divided into two or three threads at their extremities. Only two biliary vessels have been yet observed.

Genus Ranatra, Fab. differs from the preceding chiefly in the linear form of the body, in the rostrum being directed forwards, and in the character of the anterior legs, of which the haunch and thigh are slender and elongated.

These insects do not excel as swimmers. They frequently leave the water in the evening, and are good flyers. They are very voracious. The *R. linearis* occurs throughout Europe. It is pale cinerous, with a yellow tinge; the abdomen reddish beneath. It measures about an inch in length, and the setaceous appendages are as long as the body. The aigrette upon the eggs of this species consists of only two setæ. The genus is by no means numerous in species, but it occurs in the East Indies and America, as well as in Europe.

Tribe 2d, Notonectides.

In this group the two anterior legs are simply curved underneath, with the thighs of the usual size, and the tarsi pointed and thickly ciliated, and resembling those of the posterior legs. Their body is ovoid or nearly cylindrical, and thickish, or less depressed than in the preceding tribe. Their posterior legs are much ciliated, and resemble oars. They are terminated by two small indistinct hooks. They swim or row with great swiftness, and frequently turn upon their backs. They correspond to

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[1] From ναυς, *boat*, and κοϱις, *bug*.

[2] Supposed by some to have been originally a misprint for *Hepa*, a Latin word applied to the scorpion.

[3] *Annales Gen. des Sciences Physiques*, t. vii.

Hemiptera Heteroptera.

the genus *Notonecta* of Linnæus, which Latreille divides as follows.

Genus Corixa, Geoff. Rostrum very short, triangular, transversely striated. Anterior legs very short, with ciliated compressed tarsi, furnished with a single articulation. The other legs are elongated, and the middle pair are terminated by two very long hooks. Elytra horizontal. Scutellum not apparent. *Sigara* of Fab.

These insects are of an elongated form, the body somewhat flattened, the head large and vertical, the eyes triangular, the prothorax more developed transversely than in a longitudinal direction, but prolonged backwards to a point. They walk defectively, but swim and fly well. We think they never swim upon their backs, like the species of the following genus, but are usually seen as it were suspended by their extremity from the surface of the water, and prepare to dive instantly on the approach of danger. When seized they endeavour to pierce the skin of the captor with their sharp-pointed rostrum; and if they succeed in that effort, pain accompanied by swelling not unfrequently ensues. The genus is not extensive. We may here name, as the most frequent in the fresh waters of Europe, the *C. striata* (*Notonecta striata*, Linn.), which measures about five lines in length, brown, with numerous spots or little rays of a yellowish hue. The head, legs, and under parts of the body, are likewise of the latter colour.

We may here note, that Dr Leach assumes the *Not. minutissima* of Fabricius as the type of his genus *Sigara*. It resembles the preceding genus in many respects, but the body is rather ovoid than linear or cylindrical, and the thorax is provided with a scutellum.[1]

Genus Notonecta,[2] Geoff. Fab. Rostrum articulated and in the form of an elongated cone. All the tarsi with two articulations. The four anterior legs geniculate, with simple cylindrical tarsi. Elytra declined. Scutellum distinct.

The Notonectæ properly so called are characterized by the singular practice of swimming upon their backs, with their bodies somewhat inclined, their heads being elevated during their upward progress, and the contrary while they either rest suspended at the surface or descend towards the bottom of the pool. When these insects are in the act of swimming, they make use only of the middle and posterior pairs of legs, the anterior being applied closely to the chest; but when they walk at the bottom, or over the herbage of aquatic plants, in search of insect prey, they then bring the latter into active service, and merely trail the former after them, or alongside. The females deposit their eggs, which are long and white, on the stalks and foliage of water-plants. The young are produced in spring, and resemble the perfect insects, except in the want of wings. The nymphæ are equally active, and exhibit these organs in a rudimentary state. They are all, of whatever sex, age, or condition, predaceous in their disposition, and, in the absence of more ordinary food, will seize upon and cruelly devour their own species. We are acquainted with about a dozen of the genus, of which about a third inhabit Europe. The others occur in Asia, Africa, and America. The most familiarly known in this country is the *N. glauca* of Linn. (*Nepa notonecta*, Dejeer, *Mem. Insect.* iii. p. 382, No. 5, tab. 18, fig. 16, 17), figured on Plate CCXXIX. fig. 11. It is about half an inch in length, of a greenish black beneath, the front of the head of a pale green, the upper and anterior portion of the thorax whitish, the posterior half obscure. The elytra are of a yellowish-grey, with a tint of brown, their sides spotted. The scutellum is black. This insect varies considerably in its external aspect. Those with brown elytra, varied with reddish, may be regarded as *N. maculata* of Lat.

The *N. minutissima* of Linn. must not be confounded with the species so called by Fabricius. The former constitutes the genus *Plea* of Dr Leach, and differs from Notonecta in having the third point of the antennæ larger than the others. The articulations of the anterior tarsi are also of equal length, and the hooks of the posterior legs are large. The form of the body, and texture of the elytra, likewise present some disresemblances.

HOMOPTERA, Lat.

In this second great division of the hemipterous order, the rostrum or sucker originates from the inferior part of the head, close upon the chest, or even from between the two anterior legs. The elytra (almost always inclined) are semimembranous, and of the same consistence throughout. They are sometimes scarcely distinguishable in their texture from the inferior wings. The three component segments of the thorax are united as it were *en masse*, and the first is always shorter than the one following.

The genera of this section are quite dissimilar in their habits to those with which we have been previously engaged. They feed on the juices of plants. Many of the females are provided with a scaly sheath or ovipositor (called *oviscapte* by M. Marcel de Serres). This is usually composed of three dentated blades, lodged in a bivalvular groove. They use it as a kind of saw, with which to produce notches or other excavations in various plants, for the purpose of depositing their eggs in safety.

FAMILY I.—CICADARIÆ.

The genera composing this family present three articulations in the tarsi,—the antennæ are usually very small, conical or awl-shaped, and consist of from three to six portions, including the attenuated seta by which they are terminated. We owe to MM. Ramdhor, Marcel de Serres, Leon Dufour, and Straus, many excellent observations on the internal structure of these insects. According to Dufour, the stomach, or chylific ventricle, is of remarkable length. It commences by an oblong dilatation, either curved or straight, and decreases into an intestiniform canal, which returns upon itself, and opens near the origin of the ventricle, alongside the insertion of the hepatic vessels, and not far from the origin of the intestine. They are all provided with four biliary vessels. In the Cicadæ the ventricle has what Dufour calls "la forme d'une anse," the right portion being dilated into a large lateral, and frequently plaited pouch. Its superior extremity is united to the œsophagus by an upper ligament, and the other leads to the narrow, tubular, very long, reflexed prolongation, with the form of an intestine, which, after its circumvolutions, re-ascends to unite with the pouch near the insertion of the hepatic vessels. This truly singular disposition of the chylific ventricle, which, after several convolutions, finally disgorges into itself, by the completion of a circle traversed throughout by the alimentary fluid, is doubtless a circumstance not easily explained in a physiological point of view. It is, however, not the less a well determined fact, and one which constitutes the most characteristic feature in the anatomy of the Cicadæ and other Cicadariæ.[1] In the *Ledra aurita* of Fabricius, the inflated portion of the chylific ventricle is placed immediately after the crop; and there is but a single cluster of salivary sacks on each side, a character likewise observable in *Cercopis spumaria*, or Frog-spittle; while in Cicada there are two on each side. In *Membracis cornuta* the *anse duodenal* of Dufour is replaced by a short pouch, likewise attached to the œsophagus by a suspensory filament, a character peculiar to these insects.

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[1] *On the Classification of the natural tribe of Insects Notonectides, with Descriptions of the British Species*, Linn. Trans. xii. p. 10.

[2] From νωτος, *back*, and νηκτης, *swimmer*.

[3] From ὁμὸς, *equal*, or *the same*, and πτερα, *wings*,—in reference to the similar texture of the organs of flight.

1st, Stridulantes.

Antennæ composed of six articulations. Three simple eyes. This division includes the *Manniferæ* of Linnæus (Tettigonia, Fab.), and forms the

Genus Cicada of Oliv. and Lat. Head transversal. Eyes large. Prothorax broad or transversal, with a straight posterior margin; the mesothorax large, with the form of an X on its posterior edge. Elytra generally vitreous. A large scaly operculum covers a cavity on each side of the base of the abdomen in the males.

These insects differ from those that follow, not only in the structure of the antennæ and the amount of the simple or stemmatic eyes, but also in their being all destitute of the faculty of leaping. The males are musical, that is, during the heat of summer, they produce, by a peculiar structure, a loud and continuous cry or stridulation, called by courtesy a song. When we examine the lateral base of the abdomen of a male Cicada, we perceive two large scaly plates of a rounded figure, approaching that of a demi-oval cut through its smaller axis; so that each plate presents a side which is rectilinear, while the remaining portion exhibits a rounded outline. It is by the straight side that each plate is fixed without articulation, on the metathorax, of which it forms a portion. When we lift up these plates we discover a cavity on each side of the abdomen, divided into two principal chambers by a horny triangular septum. When viewed from the side of the abdomen, each cell presents anteriorly a white and plaited membrane; and lower down there is another membrane, thin, light, and transparent as glass, called *le miroir* by Réaumur. Some authors have regarded this as a kind of drum or tambour, and the seat of sound; but that organ has yet to be described. If we open the mirror from above, we perceive on each side of it another plaited membrane, moved by a very powerful muscle, composed of a great number of straight parallel fibres, and arising from the horny septum. This latter membrane is the tymbal or drum, on which the muscles act by contraction and relaxation, alternately tightening and restoring it to its original state. This is the true origin of the sound, which in fact may be produced even after the death of the insect, by jerking the muscle.[2] We may add, that M. Chabrier has perceived a stigmatic opening, not noticed by Réaumur, at the inferior junction of the mesothorax and metathorax; while Latreille has discovered on the posterior part of each tymbal a distinct hole, which, he thinks, serves for the egress of the air. Chabrier, however, is of opinion that the air makes its escape through the two stigmata placed at the base of the opercula before mentioned.[3] Further investigation will probably show that the analogues of this singular structure exist in other insects. Indeed, the principal pieces have been already recognised, though much more feebly developed, not only in the female Cicadæ, but also in certain species of the orthopterous genera *Acrydium* and *Truxalis*. In the opinion of Audouin, the plates or shutters (*volets*) are merely large prolongations of the *epimera* of the metathorax.[4]

The Cicadæ dwell on shrubs and trees, of which they suck the juices. The females, which are provided with ovipositors, lay their eggs in holes, which they form in the small branches or twigs of trees. The parts thus attacked are easily recognised by little irregularities, formed by a portion of the wood which has been raised. These elevations are placed in a row, one after the other, upon the same side of the branch. The different holes have a diameter nearly equal. Their depth is from three to four lines. They commence in an oblique direction; but as soon as they reach the pith, they become nearly parallel with the twig itself. The ovipositor does not pierce beyond the pith; and the number of eggs placed in each hole varies from four to ten. They are white, oblong, and pointed at both ends. The larvæ are white, and furnished with six feet. They soon quit their sylvan nurseries, and make their way under ground, where they gnaw the roots of plants. Their anterior legs are short, with strong dentated thighs, and are well adapted for digging. They increase rapidly in size, and are ere long transformed into nymphs. These are of a dingy-white colour, and are chiefly remarkable for their very short and inflated fore legs, which are dentated, and serve them to penetrate the earth. After living for about a year in this state, they leave the ground during the prevalence of warm weather, and, climbing up the stems of trees, their skin first hardens, and then bursts all along the centre of the dorsal line. The perfect insect then escapes from its exuviæ. It is at first very soft, and of a greenish colour; but it soon attains a firmer consistence, and various external markings make their appearance, according to the characteristic aspect of the different kinds.

These insects were well known to ancient writers, and their so-called song has been celebrated by poets from the highest antiquity. To ourselves it appeared monotonous and fatiguing, although heard not seldom among the leafy groves which shadow the fair white walls of the "Etrurian Athens." The Cicada is the insect so frequently and fondly commemorated by the Greek poets under the name of τεττιξ,—which our translators have generally though erroneously construed *grasshopper*. Linnæus, with his accustomed propriety, applied the term *Gryllus* to the locust and grasshopper tribes, and that of Cicada to the "beloved of the Athenians." The name of tree grasshopper, however, which is sometimes used, applies with sufficient accuracy to the latter, and indicates one of its characteristic habits, that of usually perching upon trees. The true grasshoppers are ground insects. The Cicadæ are scarcely known in Britain, although the species attached to ash-trees (*C. orni*) is recorded as an English insect, in common with *C. hæmatodes*. They abound in Italy and other southern parts of Europe. The Italians call them *Cicale* and the French *Cigales*, both words being no doubt derived from the Latin. They are frequently mentioned by the modern Italian poets; and Lord Byron somewhere alludes to the "shrill Cigala, people of the pines," thus recognising their *arboreous* disposition. Although held in the highest estimation as *children of the soil* by the Athenians, who used to wear golden images of them in their hair, there is no doubt that they were also regarded by the Greek nations under a less intellectual aspect. Aristotle mentions that they were used as food, and that they were particularly esteemed just before the conclusion of the nympha state. The insect which he mentions under the name of *Tettigometra*, or mother of the Cicadæ, is in fact merely that intermediate condition of nymph, prior to the development of the organs of flight. In that state, as well as when under the form of larva, it lives upon the ground, or even beneath it, feeding on herbage and the roots of plants; but when about to undergo its final metamorphosis, it climbs a tree, its outer garment bursts asunder and is thrown off as exuviæ, the wings expand their folds "voluminous and vast," and we have then the perfect insect or tree grasshopper, the Cicada of the Latins, and Tettix of the Greeks, so beautifully addressed by Anacreon:—

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[1] *Règne Animal*, v. 211. See also *Recherches Anatomiques sur les Cigales*, in the 5th vol. of the *Ann. des Sciences Nat.*

[2] *Règne Animal*, v. 214.

[3] *Essai sur le Vol des Insectes.*

[4] *Dict. Class. d'Hist. Nat.* iv. 125.

> We deem thee blest, thou grasshopper, as on the highest trees,
> Having sipp'd a little dew, thou sitt'st, like a monarch, at thine ease;
> For every thing before thee, whate'er the fields produce,
> And the fruits of every season, are intended for thy use.
> Thou art the friend of husbandmen, since harmless are thy ways;
> By mortals held in reverence, sweet seer of summer days.
> The muses love thee dearly, to Phœbus art thou dear,
> Who with that voice hath gifted thee, so musical and clear.
> Song-skilled, earth-born, song-loving one, old age to thee's no load;
> Fleshless, bloodless, passionless, thou almost art a god.

A great variety of opinion seems to prevail regarding the musical accomplishments of these celebrated insects. Virgil accused the Italian Cicadæ of bursting the very shrubs with their noise—"Et cantu querulæ rumpent arbusta Cicadæ;" and Dr Shaw in his Travels calls it, alluding to its shrilly cry, "the most troublesome and impertinent of insects." Kirby and Spence tell us that in some countries it is execrated for its deafening din. Yet some one who desired to compliment Plato, asserted that his voice was as sweet as a grasshopper's; and we may all remember the story of the rival musicians (Eunomus and Ariston), one of whom gained the victory in consequence of a Cicada settling on his harp, and supplying the place of a broken string. Even at this day the song of the *Tettigonia Tibicen* of Surinam is supposed so greatly to resemble the sound of a musical instrument, that the insect itself is called the *Harper*. The following is Mr Elton's translation of Meleager's invocation.

> O shrill-voiced insect! that with dew drops sweet,
> Inebriate, dost in desert woodlands sing;
> Perched in the spray-top with indented feet,
> Thy dusky body's echoings harp-like ring:
> Come, dear Cicada! chirp to all the grove,
> The Nymphs and Pan, a new responsive strain;
> That I, in noonday sleep, may steal from love,
> Reclined beneath the dark o'erspreading plane.

We shall here conclude our general sketch of these insects by observing that the substance used in medicine, and known by the name of *manna*, is an exudation from certain species of ash (*Fraxinus rotundifolia et ornus*) which flourish in the south of Europe. It has been observed to be frequently produced by the puncturing of the Cicadæ, which feed on the juices of those saccharine trees. The largest insect of the genus in Europe is *C. plebeia* of Linn. Its cry is very strong and shrill; and as it is well known in Italy, there can be no doubt of its being the species mentioned by Virgil. If identical with the Athenian Cicada, its voice does certainly by no means correspond in musical intonation to what might be inferred from its recorded character as a lyrist among the ancient Greeks. The pleasure produced may however depend upon association; for, as Cowper says,

> Sounds inharmonious in themselves, and harsh,
> *Yet heard in scenes where peace for ever reigns,*
> *And only there*, please highly for their sake.

It is said that the males alone are musical, which may perhaps be one reason for their continued cheerfulness; for, as the Rhodian Xenarchus has it,

> Happy the Cicadas' lives,
> Since they all have voiceless wives.

The amount of species in the genus Cicada is considerable. They are spread over almost all the regions of the earth, especially in the warmer latitudes.[1] The greater number are foreign to Europe. Our bounds will not admit of more than a brief notice of a very limited number of species. The *Cicada Orni* is a European insect, common in France and Italy. It is about an inch long, yellowish, paler beneath, but mixed with black on the upper portions. The margins of the abdominal segments are reddish. There are two rows of blackish spots on the upper wings, those next the inner margin being the smallest. Its voice is hoarse, and does not extend so far as that of several other species. This is the kind which, by wounding the tree from which it derives its specific name (a species of wild ash), causes a peculiar and honey-like fluid to flow from it. It afterwards dries and hardens, and in that state is used medicinally under the name of manna. The *C. plebeia*, Lin. (*Tettigonia fraxini*, Fab.), figured on Plate CCXXIX. fig. 13, is the largest species found in France. It is black, with some spots on the first segment of the thorax, its posterior margin, the raised and arched portions of the scutellum, and several veins on the elytra, reddish: Its cry is strong and shrill. The *C. hæmatodes* is black, with the front of the thorax and legs spotted. The edges of the abdominal segments, and the reticulations of the elytra, are red. This species occurs in the south of France, but is rare in the vicinity of Paris. Its voice is weaker than that of the preceding species. Olivier has described sixty-six species in all.[2] We are indebted to Stoll for a monograph of the Cicadæ, already referred to in a subjoined note.

2D, MUTÆ.

Antennæ with only three distinct articulations. Two ocelli or simple eyes. Legs, in general, adapted for leaping. Neither sex provided with organs of sound. The elytra are frequently coriaceous and opake, and the females of many species are observed to envelope their eggs in a white and cottony substance.

A. *Fulgorellæ.*

Antennæ inserted immediately beneath the eyes, and the front frequently prolonged into a muzzle, of variable figure according to the species.

GENUS FULGORA.[3] Front of the head prolonged or expanded into a muzzle. No appendages beneath the antennæ. Thorax of two apparent segments,—the posterior margin of the first straight, of the second triangular.

These insects are remarkable for the varied and beautiful markings of their elytra and wings, and for the singular form of their expanded muzzles, from which a luminous or phosphoric emanation proceeds during the night. Hence several of the species are known (in common with *Elater*, *Lampyris*, and other coleopterous kinds) under the name of fire-flies. The greater number of the species are exotic, and inhabit the sultry regions of Cayenne, Guadaloupe, Senegal, the East Indies, and China. They

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[1] *Encyclopédie Méthodique*, t. v. p. 742. See also Stoll's *Représentations exactement coloriée d'après nature des Cigales et des Punaises.*

[2] In *Encyclop. Méthod.* v. 742. See also Latreille's *Gener. Crust. et Insect.* iii. 154; and the *Syst. Rhyng.* of Fabricius, genus *Tettigonia.*

[3] From *fulgor*, splendour.

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dwell on trees, but their special manners are but slightly known. We shall here indicate a few of the more noted species.

F. laternaria, Linn. is a large and remarkable insect from South America, drawn and described in most illustrated works on entomology. Its muzzle is nearly straight as to its direction from the head, but it is vesicular and inflated, or swollen out and rounded, at the sides and extremity. The ends of the under wings are pleasantly varied with black and yellow, in the form of an expanded spot, resembling the eye of a peacock's feather. Madame Merian informs us, that from the head or front of this species a light is seen to shine during the darker hours, so clear and brilliant that it is easy to read by its rays. She adds, that during the day it is transparent as a bladder, and radiated with red and green. The indefatigable and accurate Réaumur, desirous to ascertain by anatomical investigation the proximate cause of this curious phenomenon, opened one of these vesicular expansions, but he found it empty, except of air, and containing no organic structure. We must bear in mind, however, that the individual examined was in a state of desiccation. The species is common at Guadaloupe and Cayenne, where it is known by the name of fire-fly. It flies well, and hovers habitually about the summits of the tallest trees. Its luminous faculty has been sometimes called in question, especially by M. Richard, who captured many at Cayenne, but never saw them shine. Yet the testimony of Madame Merian, and the general application to the species of the name of *mouche à feu*, notwithstanding the fruitless results of Réaumur's examination, suffices to establish that fact. It is probable, however, that the phosphoric emanation from this and other species is only perceptible at certain seasons of the year, and this consideration may explain the discrepancy arising from M. Richard's observations. *F. candelaria*, Fab. (Plate CCXXIX. fig. 12), is a native of China and other eastern countries, and is very abundant in collections. It is known among us by the name of *Lantern fly*, and may be easily recognised by its long cylindrical snout, arched in an upward direction, its greenish reticulated elytra, and orange-yellow wings with black extremities. At night this insect glitters by thousands among the dark recesses of the Banyan tree, which

> ....to Indians known,
> In Malabar or Deccan spreads her arms,
> Branching so broad and long, that in the ground
> The bended twigs take root, and daughters grow
> About the mother-tree, a pillar'd shade
> High overarch'd, and echoing walks between.

And they are likewise observed to dance in perpetual motion around the outmost branches of the spreading tamarind, producing a brilliant and singularly beautiful effect. *F. Europæa*, Lat. (Stoll, *Cigales*, pl. xi. fig. 51), occurs in the south of France, Italy, and the islands of the Mediterranean. Its front assumes the form of a conical advancement, with three raised lines above and five below. The elytra and wings are transparent, with green reticulations. There are three raised lines on the thorax.[1]

GENUS OTIOCERUS, Kirby. Muzzle advanced. Simple eyes wanting. Two small appendages beneath each antenna.

GENUS LYSTRA, Fab. Head transverse, and without any prolongation in the form of muzzle. Two simple eyes. Second articulation of the antennæ granular, and almost round.

The species of this genus at first sight resemble small *Cicadæ*. The extremity of the body, in the females, is furnished with little bundles of cotton threads, beautifully white, with which, it is presumed, they surround their eggs. We are acquainted with many species from China, the East Indies, and South America. We shall here mention only *L. lanata*, Fab. (*Cicada lanata*, Lin.), of which the sides of the front are red, and the extremities of the elytra black, with points of blue. We receive it from Cayenne and the Antilles.

We shall here indicate a few genera, into the detailed history of which we cannot enter. The CYXII of Latreille resemble Lystræ, but the second joint of the antennæ is smooth and cylindrical. Under the appellation of TETTIGOMETRA, Latreille has separated certain insects analogous to the preceding, but with the antennæ lodged between the posterior and lateral angles of the head, and those of the anterior extremity of the thorax. The eyes are not projecting.[2] The preceding genera are provided with simple eyes; but in such as follow, these organs are wanting.

The species with large elytra, and the prothorax shorter in the middle than the mesothorax, compose the genus PÆCILOPTERA of Latreille and Germar (*Flata* of Fabricius).[3] In ISSUS, Fab. the prothorax is as long at least as the mesothorax; and the elytra, scarcely longer, or sometimes shorter, than the abdomen, are dilated at their base, and then narrowed.[4] Sometimes the antennæ are at least as long as the head, and are most frequently inserted in an inferior emargination of the eyes. The genus ANOTIA of Kirby resembles Issus in the insertion of the antennæ.[5] In ASIRACA of Lat. (*Delphax* of Fab.) the antennæ are inserted in an inferior emargination of the eyes, and are as long as the head and thorax united. Their first joint is usually longer than the second, and is compressed and angular. In DELPHAX, as constituted by Latreille, the antennæ are similar in their insertion, but they are never much longer than the head, and their first joint is much shorter than the following one, and without ridges. The simple eyes are apparent. The genus DERBE of Fab. is allied to Anotia. The species are little known. They are all exotic, and most of them come from South America.

B. *Cicadellæ*.

Antennæ inserted between the eyes. Latreille subdivides this portion of the family of Cicadariæ into the following genera.

He commences with the species which, with the exception of a few (the LEDRÆ), formerly composed the genus *Membracis* of Fabricius. The head is much inclined or lowered anteriorly, and prolonged to an obtuse point, or under the form of a clypeus, more or less semicircular. The antennæ are always very small, terminated by an inarticulate seta, and inserted into a cavity beneath the margin of the head. The prothorax is sometimes dilated and horned on either side, prolonged and restricted posteriorly to a point or spine, either simple or compound, sometimes elevated longitudinally along the back, compressed into a sharp edge or crest, and sometimes projecting and pointed forwards. The legs are scarcely spiny.

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[1] For the other species of this genus see the works of Stoll and Fabricius, last cited, and the *Encyclop. Méthod.* article *Fulgore.*

[2] Germar, *Magazin der Entomologie*, iv. 7.

[3] *Gener. Crust. et Insect.* iii. 165; *Mag. der Ent.* iii. 219, iv. 103–4.

[4] *Systema Rhyngotorum*, p. 199.

[5] *Linn. Trans.* xiii. pl. i. figs. 9, 10, 11, 15.

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a.

No apparent or exposed scutellum properly so called.

*

Tibiæ, especially the anterior, strongly compressed and foliaceous. Upper part of the head always forming a kind of semicircular clypeus.

Genus Membracis, Fab. Prothorax elevated, compressed, and foliaceous along the middle of the back.

Of this pretty numerous genus we shall notice only *M. foliata*, Fab. (Plate CCXXIX. fig. 14), which is of a blackish brown, the front advanced, flattened, the thorax marked by an arch and band of white. The latter part is greatly elevated, flattened laterally, forming a salient crest, advancing over the head, which it almost entirely covers, and terminated posteriorly by a point prolonged beyond the abdomen. The elytra are oval, longer than the wings. The legs are elongated, flattened, rather broad. The anterior tibiæ are shorter, of an oval form, and flattened. The native country is Cayenne.

Genus Tragopa, Lat. Prothorax presenting on each side a horn or salient point, without any intermediate elevation, and prolonging itself posteriorly into an arched projection of the length of the abdomen, and occupying the place of the scutellum.

This genus is composed of certain species from Brazil, which M. Latreille regards as analogous to *M. glabra*, *albimacula*, and *xanthocephala* of Germar.

* *

Tibiæ of the ordinary form, not foliaceous.

Genus Darnis, Fab. Posterior prolongation of the prothorax covering almost the whole, or the greater portion, of the upper part of the abdomen and elytra, and forming an elongated and arched triangle.[1]

Genus Bocydium, Lat. Elytra entirely or in greater part exposed, the posterior and scutellar prolongation of the prothorax being narrow, and more or less lanceolate or spiniform.

The *Centrotus horridus*, *trifidus*, *globularis*, *clavatus*, and *claviger*, of Fabricius, belong to this genus.

b.

Scutellum partially exposed, even although the prothorax is prolonged;—the posterior extremity of the latter offering a transverse suture, which distinguishes it from the scutellum.

Genus Centrotus,[2] Fab. Similar to *Membracis*, but the thorax is dilated horizontally, and covers only a part of the body.

C. *cornutus*, Fab. (*Cicada cornuta*, Linn. Plate CCXXIX. fig. 15), is of a blackish-brown, the thorax with a horn on each side, and prolonged posteriorly to a sinuated point of the length of the abdomen. This species measures about four lines in length. It occurs in France, and other parts of Europe, in woods, on ferns, &c. and is known by the name of *petit diable*. *C. genistæ*, Fab. is of an obscure brown, the thorax without horns, but terminated posteriorly by a straight sharp point, as long as the half of the abdomen. It is only half the size of the preceding, and occurs on the broom. It is called *demi-diable* by the French.

M. Latreille now proceeds to those species of which the head, if not upon a level with, is scarcely lower than, the prothorax, and is horizontal or slightly inclined when seen from above. The prothorax is neither elevated in the centre, nor posteriorly prolonged, and offers at most some lateral dilatations. The mesothorax presents itself under the form of an ordinary-sized triangular scutellum. The elytra are always entirely exposed, and the posterior tibiæ at least are spinous.

In several genera the thorax bears the form of an irregular hexagon, prolonged and narrowed posteriorly, and terminated by a truncation, serving as a support to the base of the scutellum, which it frequently receives into itself,—the truncated portion being concave or emarginate. In the genus Ledra, Fab. the vertex is triangular, and bears the ocelli. The antennæ are inserted upon or above an ideal line drawn from one eye to another. The head is very flat before the eyes, in the form of a transverse clypeus, arcuated and terminated in the centre of its anterior margin by an obtuse angle. All the under parts of the head are plane, or on the same level. The sides of the prothorax are raised in the form of rounded horns. The posterior tibiæ are much compressed, and as if margined exteriorly by a dentated membrane. The *Cicada aurita* of Linn., or *grand diable* as it is called by Geoffroy, belongs to this genus. In the genus Cercopis, Fab. the third joint of the antennæ is conical, and terminated by an inarticulate seta. Of this genus *C. sanguinolenta* is a well-known and ornamental British species, as is also *C. spumaria*, Linn. of which the larva inhabits a white foam frequent on the leaves and stalks of various plants, and called *frog-spittle* in England—*gowk-spittle* in our northern parts of the kingdom. The latter species is by some classed in the genus *Tettigonia*.

In other genera of Cicadariæ, which terminate our present family, the prothorax is scarcely if at all prolonged posteriorly, and terminates, at the height of the origin of the elytra, by a nearly straight line, the length of which is nearly equal to the breadth of the body. The scutellum, measured at the base, occupies a great proportion of that breadth. Here are ranged the genera Eulopa, Eupelix, Penthimia, Jassus, and Tettigonia properly so called.[3]

FAMILY II.—APHIDII.

These singular insects are distinguished from those of the preceding family by the tarsi, which have only two articulations, and by the antennæ, filiform or setaceous, longer than the head, and composed of from six to eleven articulations. Such as possess organs of flight have always two elytra and a pair of wings. The species are usually very small,—their bodies generally of a soft consistence, the elytra and wings nearly alike, or differing merely in size and thickness. They lay a prodigious number of eggs, and their mode of production is in other respects very remarkable.

In some the antennæ consist of from ten to eleven articulations, of which the last is terminated by a couple of setæ. These are leaping insects, and compose the genus Psylla of Geoffroy (*Chermes*, Linn.). They are known under the title of *faux-pucerons* to the French naturalists, as distinguished from the true Aphides after mentioned. They live on trees and various plants, by the juices of which they are nourished. Both sexes are winged. The body of the larvæ is usually very flat, the head large, the abdomen rounded posteriorly. Their feet are terminated by a small membranous vesicle, furnished beneath with a couple of hooks. The nymphs are distinguishable by four broad flat dorsal portions, which constitute the sheaths of the incipient wings and elytra. Several species are covered during both of those immature conditions

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[1] For the species, see the *Systema Rhyngotorum* of Fabricius.

[2] From κεντρον, *spine*, and ωτος, *ear*.

[3] See the fourth volume of Germar's *Magazin der Entomologie*, and the *Règne Animal*, t. v. p. 222–3.

Hemiptera Homoptera.

by a white and cottony substance, disposed in flakes. Their fæces form threads or masses of a gummy and saccharine nature. Several species, by the wounds which they occasion to plants while sucking their juices, occasion the growth of peculiar excrescences on the buds and leaves, resembling gallnuts. Of these is *Psylla buxi* (*Ch. buxi*, Linn.), which is green with yellowish-brown wings. Mr Stephens has named a great many British species as belonging to this genus.[1] Latreille has founded the genus Livia upon a species which dwells among rushes (Plate CCXXIX. fig. 17). The antennæ are much thicker near the base than towards the extremity.

In other Aphidii the antennæ have only from six to eight articulations, of which the last is not terminated by a couple of setæ.

Some have the elytra and wings linear, fringed with hairs, and placed horizontally upon the body, which is of an almost cylindrical form. The rostrum is very small or indistinct. The tarsi are terminated by a vesicular article, unfurnished with hooks. The antennæ consist of eight granular articulations. Such are the species which form the genus Thrips of Linn. (Plate CCXXIX. fig. 18). These insects are very small, extremely active, and seem to leap rather than fly. When teazed, they raise and recurve the extremity of the abdomen, after the manner of the Staphylinidæ. They live among flowers and other parts of plants, and beneath the bark of trees. We may add, that although Latreille did not perceive in the organization of the mouth of these insects any characters essentially different from such as distinguish that organ among the other component parts of the homopterous Hemiptera,—yet M. Straus, who has studied the subject very laboriously, and with his wonted intelligence, is of opinion that the genus Thrips belongs in fact to the orthopterous order.

Others have the elytra and wings oval or triangular, without fringe, and inclined or tectiform. The rostrum is distinct. The tarsi are terminated by two hooks. The antennæ consist of from six to seven articulations. Such are the species which compose the great genus *Aphis* of Linn. which is now divisible as follows.

In the genus Aphis properly so called, the antennæ are longer than the thorax, of seven articulations, of which the third is elongated. The eyes are entire, and the abdomen is furnished with two horn-like projections at its posterior extremity. The species dwell together in society on various trees and plants, of which they suck the juices. They walk very leisurely, and cannot leap. The two horn-like processes just mentioned are hollow tubes, from which a drop of transparent liquid frequently exudes. It partakes of the property of sugar, and is much sought after by ants, who suck it with avidity from the living Aphides. This curious fact was first noticed by M. Boissier de Sauvages, and has since been amply confirmed by M. P. Huber. The desired liquor seems to be given out voluntarily by the aphis, when solicited so to do by a gentle tap from the ant's antennæ. A single aphis may be sometimes seen surrounded by three or four ants, all in the act of deriving from it a plentiful and nectareous meal.[2] The congregations of the Aphides consist, in spring and summer, of apterous individuals, and of nymphæ with undeveloped wings. All of these are females, which give birth to *living young, et sans accouplement préalable.* The males, which consist both of winged and apterous insects, are produced towards the end of summer, or during the autumnal season. They fecundate the last broods produced by the females first mentioned; which broods consist of apterous females, differing from their progenitors in requiring impregnation prior to the continuance of their kind. They lay *eggs* soon after the sexual intercourse, and these remain in the crevices of trees, &c. throughout the winter, and in spring produce the broods above alluded to, which are capable of producing living young, without assistance from each other. "L'influence d'une première fécondation s'étend ainsi sur plusieurs générations successives. Bonnet, auquel on doit le plus de faits sur cet objet, a obtenu, par l'isolement des femelles, jusqu'à neuf générations dans l'espace de trois mois."[3] M. Duvau has recently added some observations to those of Bonnet and Réaumur on this singular subject.[4] By this extraordinary process of production, vast multitudes are brought forth during a favourable season, and the injury to vegetation, by the absorption of the juices, and the obstruction of the natural pores, is consequently great. Réaumur calculates, that in the course of five generations, a single mother may be the means of producing 5,904,900,000! But fortunately they are liable to the attacks of numerous enemies, and are greedily devoured by many other insects. The larvæ of the genus *Hemerobius*, those of different dipterous species, and of the *Coccinellæ* or lady-birds, make the helpless Aphides their constant prey. We cannot here describe the species, but shall content ourselves by naming a few familiar examples. *Aphis rosæ* (Plate CCXXIX. figs. 19 and 20) is a small green species, very abundant on the younger shoots of roses, the flowering of which it seems to damage or destroy. Its hordes may be killed by dipping the affected branch into soapy water. *A. quercus* occurs on the oak, and is remarkable for the great length of its beak, which is at least three times as long as the body. It is of a brown colour. *A. fagi* is attached to the beech tree, and covers itself, as do many other species, with a white and cotton-like down, which exudes from its body. Including the genus *Eriosoma* of Leach, we have above fifty species of aphis in Britain. In the genus Aleyrodes,[5] Lat. (*Tinea*, Linn.), the antennæ are short, composed of six articulations, and the eyes are emarginate. *A. Chelidonii* of Lat. (*T. proletella*, Linn.) is found upon the celandine (*Chelidonium majus*), and other plants. It resembles a little moth. The larva is oval, flat, and shaped like a small scale. The nymph is fixed and enclosed in an envelope, so that its transformations differ from those of its congeners. Indeed the somewhat anomalous character of this insect has been the cause of its being described under a great variety of names.[6] Mr Stephens enumerates five British species, including the one just mentioned.[7]

FAMILY III.—GALLINSECTA.

The insects of this family seem to have only one articulation to the tarsi, and are generally so described. It

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[1] *Systematic Catalogue*, part ii. p. 361.

[2] The viscous drops so frequent on the foliage of many trees, and commonly known by the name of *honey-dew*, is this secretion from the Aphides. We have seen it falling from a willow tree like a gentle and continuous shower, and ascertained its origin by discovering at the same time millions of these insects incrusting the upper branches, and each giving out from time to time a minute drop of nectareous fluid.

[3] *Règne Animal*, t. v. p. 227.

[4] *Ann. des Sciences Nat.* t. v. p. 224.

[5] From *αλευρος*, *flour*, in allusion to the farinaceous powder by which these insects are often covered.

[6] See Geoffroy, *Hist. des Insect.* t. ii. p. 172; Réaumur, *Mem. 7th*, t. ii.; and *Dict. Class. Hist. Nat.* t. i. p. 211.

[7] *Systematic Catalogue*, part ii. p. 367.

Hemiptera Homoptera.

is the opinion, however, of M. Dalman, that those parts consist of three joints, with a single hook at the extremity.[1] The males want the rostrum, and have only two wings laid horizontally on the body; their abdomen is terminated by a pair of setæ. The females are winged and provided with a rostrum. The antennæ are filiform or setaceous, and consist, for the most part, of eleven articulations. There are only nine in the males of the species described by M. Dalman. These creatures form the noted genus *Coccus* of Linn. commonly called cochineal insects. They are also known by the name of *Chermes*,[2] and their history and attributes are sufficiently remarkable.

We may frequently perceive on the branches of various trees multitudes of small oval or rounded bodies resembling scales, adhering closely to the wood, and presenting no indications of any external organs. These are insects of the genus Coccus, the *progallinsectes* of Réaumur. Their history was for a long period extremely obscure, and the species employed in commerce was even at one time regarded as a kind of grain. It was only towards the termination of the seventeenth century that M. Plumier clearly established their insect origin. We are indebted to Réaumur for a complete history of the life and transformations of the European kinds. The larvæ of both males and females, on first quitting the egg, are tolerably active, and run about among the leaves and branches. They are, however, so extremely small at that period, as not to be distinctly discernible without the aid of a microscope. They are flat, ovular, apterous, with short and indistinctly articulated antennæ. The males have no apparent organs of manducation, although the females are furnished with a small, extremely short, almost conical beak, inserted between the first and second pair of feet, nearly perpendicular in its direction, and composed of a four-jointed sheath containing a sucker of three pieces. It is with this instrument that they pump the juices of the leaves and tender stems. They also fix themselves from time to time for the purpose of changing their skin, and after arriving at a certain size, they become definitely fixed in some chosen spot, usually at the bifurcation of a branch, where they form a little nest, protected by a tapestry of cotton. They then attain the perfect state, and are apterous (we speak of the females) even in that otherwise complete condition. Their head is semicircular, their mouth is still formed of the beak which existed in the larva state, and the eyes are small. The thorax is not easily distinguished from the abdomen, the segments of which are distinct. When the insect has attained its full growth, its abdomen is found filled with a multitude of minute eggs. The larvæ of the males, though by no means rare, are much less numerous than those of the other sex. Their mode of sustenance, owing to the want of the sucker, is not distinctly known; but they increase in size, and after a time their skin hardens, and serves as a cocoon, in which they undergo their transformation to the nympha state. In the latter condition they are remarkable for the anterior pair of legs being directed forwards. Towards the beginning of spring these cocoons open at their posterior portion, and the perfect male insect comes forth stern foremost. It is of a more elongated form, with a round head furnished with two small eyes and a pair of rather long antennæ. The thorax is rounded, and has attached to it a pair of long wings, folded horizontally one over the other, and very delicately veined. (For a male Coccus see Plate CCXXIX. fig. 16; the female is shown by figures 21 and 22). The male is less than the female, and more active, although it uses its wings very sparingly. As soon as it attains the perfect state, it sets off in search of the other sex, which still remains fixed in the nest, as formerly mentioned. The oviposition of the female is another remarkable peculiarity in the history of these insects. Though excluded from the body, the eggs do not appear externally, but are made to pass beneath the abdomen, and between it and the cotton tapestry above alluded to. In proportion as the insect becomes empty, the lower surface of the abdomen approaches the upper one, so as to leave beneath the body a kind of arch or cavity for the reception of the eggs. The perfect female never stirs a step in the course of her life, but having laid her eggs she dies, and her body shrivels up and hardens, and thus forms a cocoon or covering for the incipient young. These, as soon as hatched, work their way from beneath the dead body of their parent, making their escape by its posterior extremity.

These curious insects are certainly hurtful to vegetation, by causing a too abundant transudation of their juices; and they consequently excite the jealousy of those who cultivate the finer trees, such as the peach, the orange, the olive, and the fig. Certain species attack also the roots of plants. But, upon the whole, the advantages which we derive from this genus of insect amply counterbalance whatever injuries it may occasionally inflict upon us. The species are very numerous. We shall here notice only a few of the more remarkable.

Of the kind called Kermes, is that known to naturalists by the name of *Coccus Ilicis*, of which the female attains to the size and form of a pea. It is of a violet-black colour, covered by a whitish powder. This species is common over the south of Europe on the evergreen oak, and appears to be widely distributed over many of the south-eastern countries of the ancient world. It occurs abundantly in Spain, where it attaches itself chiefly to the twigs and leaves of a small species of spiny-leaved oak, frequent in the southern parts of that romantic kingdom, especially on the slopes of the Sierra Morena. Many of the inhabitants of Murcia have no other means of subsistence than those procured by collecting the Kermes. Women are usually so employed, and they scrape the adhesive insects from the trees by means of their nails. Though supplanted over the greater portion of Europe by the introduction of the more famous cochineal (*Coccus cacti*), which is an American species, it is still extensively used in India and the Persian dominions.[3] It has been employed from time immemorial to impart a blood-red or crimson dye to cloth, and was known to the Phœnicians by the name of *Thola*. It was called coccus (Κοκκος) by the Greeks, and kermes or alkermes by the Arabians. According to Beckman, the epithet *vermiculatum* was applied to it during the middle ages, when its insect origin came to be generally understood, and hence is derived our English word vermilion. The French term *cramoisi* is evidently from the Arabic. It is supposed to have been by means of this substance that the curtains of the tabernacle (Exodus, xxvi. &c.) were dyed of a deep red (which the word scarlet then implied, rather than the colour so named in more modern days, which was unknown in the reign of James I. when our Bible was translated); and from the same source have been derived the imperishable reds of the Flemish tapestries. The scarlet afforded by cochineal was unknown in its highest perfection till the year 1630, when the singular power of the oxide of tin in exalting its colours was discovered in Holland; it was soon after communicated to one of the celebrated MM. Gobelins of Paris, and may have contributed to the perfection of their tapestries.[1] Since the preparation of Morocco leather has been established in this country, cochineal has been employed to produce the beautiful colour of what is called red morocco; but in Persia, Armenia, Barbary, and the Greek islands, a similar colour was originally produced by the use of either kermes or lac.[2] The colouring matter of kermes is regarded by Dr Bancroft as identical with that of cochineal, but combined with some astringent matter derived from the tree on which it feeds.

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[1] See his Memoir in Swedish,—*Om nagra svenska arter of Coccus*, Stockholm, 1826.

[2] Be it remembered, however, that the genus *Chermes* of Linn. corresponds to *Psylla* of Lat. already described, and not to our present species, which are the true *Kermes* of Geoffroy, Réaumur, and Olivier.

[3] Kirby and Spence's *Introd. to Ent.* and Bochart's *Hierozoic.*

The substance called *lac* is also the produce of an insect of the Coccus kind. It is collected from various trees in India, where it is used in the fabrication of beads, rings, and other ornaments of female attire. When mixed with sand it forms grindstones; and, added to ivory black, and previously dissolved in water with a little borax, it composes an ink which, when dry, is said to be capable of resisting a considerable degree of damp or moisture. In this country, according to the different states in which it is imported, it is called stick-lac, seed-lac, lump-lac, or shell-lac. It is chiefly used in the making of varnishes, japanned ware, and sealing-wax, although during late years it has been applied to a still more important purpose, as originally suggested by Dr Roxburgh, that of a substitute for cochineal in dyeing scarlet. The first preparations from it with this view were made in consequence of a hint from Dr Bancroft; and large quantities of a substance termed *lac-lake*, consisting of the colouring matter of stick-lac, precipitated from an alkaline lixivium by alum, were manufactured at Calcutta, and sent to this country, where at first the consumption was so considerable, that in the three years previous to 1810 the sales at the India house equalled in point of colouring matter half a million of pounds weight of cochineal.[3] "More recently, however, a new preparation of lac-colour, under the name of *lac-dye*, has been imported from India, which has been substituted for the lac-lake, and with such advantage, that the East India Company are said to have saved in a few months L.14,000 in the purchase of scarlet cloths dyed with this colour and cochineal conjointly, and without any inferiority in the colour obtained."[4] The only mordant formerly used with kermes was alum, and the colour communicated was blood-red; but Dr Bancroft ascertained, that with the solution of tin used with cochineal it was capable of imparting as brilliant a scarlet as that dye, and one perhaps more permanent. It must be borne in mind, however, that as ten or twelve pounds of kermes contain no more colouring matter than a single pound of cochineal, the latter at its ordinary price is, after all, the cheapest.

Several other curious and valuable products are obtained from insects belonging to the genus Coccus, or to one nearly allied in its natural character and attributes. The *pe-la*, for example, or white wax of the Chinese, is derived from an insect, apparently a Coccus, described by the Abbé Grozier; and a non-descript Indian species produces a wax analogous to pe-la, first noticed by Dr Anderson under the name of white lac. It is obtained in great quantities in the vicinity of Madras; but Dr Pearson's experiments do not countenance the idea, at one time rather sanguinely entertained, that it might be advantageously used for making candles.[5] Geoffroy long ago attributed to a species of kermes the faculty of producing a sugary substance, of a white colour, resembling manna; and Captain Frederick has described an article of that nature under the name of *Gez*, found in Persia and Armenia; but he seems doubtful whether to attribute to it an animal or a vegetable origin.[6] More recently, however, General Hardwicke has described an Indian insect, under the name of *Chermis mannifer*, of the size of the domestic bug, and of a flattened oval form, with a rounded tail. From its abdomen a quantity of saccharine substance is exuded, and assumes the form of a bunch of feathers, with a consistence like that of snow. These insects are found on the branches and leaves of trees in millions, and they there produce this feather-like secretion, till it becomes elongated, and, dropping on the leaves, hardens upon them into a substance resembling the most beautiful wax.[7]

Of the European species, in addition to *C. Ilicis*, already described, we may mention *C. adonidum*, now naturalized in our hot-houses, where it is very destructive, and *C. polonicus*, which yields a colouring matter almost as beautiful as the Mexican cochineal; it attacks the roots of *Scleranthus perennis*, and other plants, and is still used as a dye in Russia.

Before closing this branch of our subject, we must devote a few lines to the cochineal insect properly so called, the *Coccus cacti* of naturalists (Plate CCXXIX. figs. 16, 21, 22). This species, so important in a commercial point of view, and in relation to our arts and manufactures, is a native of Mexico, where it was assiduously cultivated at a period long anterior to the European conquest of that country. We shall not describe its appearance, as that will be better understood by an inspection of the figures just referred to. There are several varieties, named in general from the provinces where they are bred; and of these, that called Mastique or Mèsteque is regarded as the best. It is cultivated on a tree called Nopal by the Indians (*Cactus cochenilifer*, Linn.) and its colour is by some attributed to the juices of that plant. It is the female insect that is so highly valued for the incomparable beauty of its colour. It is imported to Europe in the form of a little grain, convex on one side, concave on the other, and exhibiting traces of the abdominal segments. In the year 1736 there was sent to Europe about 700,000 pounds weight of this minute creature, a quantity worth L.700,000 sterling. Humboldt states the quantity imported about the period of his inquiries to have been 32,000 arrobas, worth in South America L.500,040 sterling,[8]—"a vast amount to arise from so small an insect, and well calculated to show us the absurdity of despising any animals on account of their minuteness."[9] Dr Bancroft calculates the annual consumption of cochineal in Great Britain at about 750 bags, or 150,000 pounds weight,—worth L.375,000 sterling at recent prices. The natives of those districts in which the cochineal is reared form plantations of the nopal tree near their dwelling-houses. It grows freely from cuttings, and the latter are fit for the reception of the insect in eighteen months. Eight or ten females are put into a small nest formed of tufts of a thread-like substance collected from a species of palm, or of any other cottony matter. These nests are attached to the spines of the nopal, upon the side facing the rising sun, and the insects are placed in them about the middle of October, a period at which good weather usually commences in Mexico after the rains. The eggs are soon laid and hatched, and the progeny spread in vast numbers over the plant, each female producing upwards of a thousand young. According to M. Thierry de Menonville,[1] six generations are produced in a year, and they might be collected at all seasons, but for the destruction produced among them by the periodical rains. The first collection takes place about the middle of December, and the last in the month of May. They are detached by means of a knife with the edge blunted, to prevent injury to the nopal tree. When the first gathering is made, the nests are taken away, and the dead females (those placed on the nopal in October) are likewise picked off. These are lighter and less valuable than such as are taken off alive and full of young; the former losing three fourths, the latter two thirds, during the process of drying. As soon as dried, however, both kinds may be kept for any length of time, without any further loss of either weight or colour. They are killed by different processes. Some put them in a basket, which they dip in boiling water, and afterwards dry them by exposure to the sun; others place them in an oven, or on plates of heated iron. The various external colours of the insect, as we afterwards see it in Europe, depend upon the mode of putting it to death. Those which have been killed by being dipt in hot water (the method regarded as the best), lose a portion of the white powder with which they were previously invested, and acquire a brownish-red colour. When so treated, they pass under the name of *renagrida*. When killed in an oven they retain the white powder, remain externally of a grey colour, and are called *jarpeada*. Such as are placed on plates of heated iron become of a blackish hue, and are then named *negra*. When cochineal insects are forced from the tree, they speedily die, even if no further violence is offered them; because their sucker, being fixed in the wood, is unavoidably dislocated and broken off by the act of removal. It is necessary, however, to put them to death, because they might otherwise live for a short time, and meanwhile produce their young, the loss of which would diminish the quantity of colouring matter.

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[1] *Quarterly Review*, vol. ix. p. 210.

[2] *Experimental Researches concerning the Philosophy of Permanent Colours*, &c. by Edward Bancroft, M. D. vol. ii. p. 167.

[3] Bancroft, *ut supra*.

[4] *Introd. to Ent.* vol. i. p. 318.

[5] *Linn. Trans.* 1794.

[6] *Transactions of the Bombay Literary Society*, vol. i.

[7] *Description of Gez or Manna, in the Asiatic Researches*, vol. xiv. p. 182.

[8] *Political Essay on New Spain.*

[9] *Introduct. to Ent.* vol. i. p. 316.

The other most frequent variety of cochineal is called *sylvester*, on account of its being commonly collected from a species of cactus which grows wild, or without culture. It is of smaller size, and much less valuable in relation both to the amount and quality of the colour which it yields. We have not yet ascertained to our own satisfaction whether it is a mere variety or a distinct species. Although it occurs naturally upon a wild spiny cactus, it is also cultivated upon the nopal or garden species, for the sake of the greater facility of collection. So great indeed is the difference in this point, that in one day a single labourer will gather from the latter a quantity which, when dry, will amount to the weight of three pounds,—whereas from the former the most persevering hand will not obtain in that time much more than a couple of ounces. Moreover, when cultivated on the garden nopal, the *sylvester* cochineal attains to as large a size as the *mastique*.

Various attempts have been made to introduce the culture of the cochineal into our eastern possessions, although these, so far as we are informed, have not yet been attended with any marked success. The old Spanish government manifested great jealousy on the subject; and we are not aware that the true kind has been yet imported, although the court of directors at one period offered a reward of L.6000 to whoever should effect its introduction to India. Colonel Bory St Vincent informs us that attempts have recently been made, and with a fair prospect of success, to effect its cultivation near Malaga, in Spain.[2] We shall conclude our sketch by observing that considerable care is requisite to preserve these insects from the attacks of their natural enemies, of which one of the chief is the larva of a species of Coccinella, which sucks them to death, and leaves nothing but the skin. A very destructive foe is also described as being a caterpillar, of an inch in length, and the thickness of a crow-quill, which, it is said, would soon destroy the race if allowed to continue its attacks without any interference on the part of the higher powers.[3] It is said that a species of *Ptinus* also feeds upon them freely. Besides these direct enemies, there is another insect, with the exact nature of which we are not acquainted, which lives in common with the cochineal upon the juices of the nopal, and by so doing greatly interferes with the health and progress of the more valuable species. Among its larger, if not more formidable enemies, we may mention a mouse, which is said always to prefer the mastique or finer cochineal to the sylvester or wild species, because the cottony matter with which the latter is invested produces discomfort by entangling in its teeth. Both kinds are moreover subjected to the attacks of numerous birds.

ORDER IV.—NEUROPTERA.[4]

Distinguished by four naked or transparent wings, reticulated or interlaced by a delicate network, and usually of the same size as well as texture. The mouth is adapted for mastication, that is, furnished with mandibles and true maxillæ, and never assumes the tubular form. The abdomen does not possess a sting, and is rarely provided with an ovipositor. The antennæ are usually setaceous, and composed of numerous articulations. The head is furnished with two or three simple eyes. The thorax is formed of three segments, intimately united to each other, though perceptibly distinct from the abdomen; the first of these segments is usually very short, and in the form of a collar. The number of joints of the tarsi varies. The form of the body is for the most part elongated, and its texture rather soft and delicate. The abdomen is always sessile. Many of the species are carnivorous, both in the larva and perfect state.

This beautiful and very varied order has been divided into two by Mr Kirby, by the separation of the genus *Phryganea* of Linn., which the English naturalist raises to the rank of an order under the name TRICHOPTERA. It might also have simplified the characters of the order if we had left in it only those which possess reticulated wings; but as some of the latter exhibit a difference in the texture of the organs of flight, it is difficult to assign rigorous characters to the neuropterous tribes, if we attach a high importance to the wings. "Of all the Linnæan orders," says Mr Kirby, "this appears to consist of the most discordant tribes; so that it seems next to impossible to construct a definition that will include them all, unless indeed we admit M. Latreille's idea, adopted by Mr Macleay, that a varied metamorphosis is its essential character; or, to speak more largely, variety itself seems the characteristic of the insects composing it in every state, and there is scarcely a common distinctive character in their perfect state, upon detecting which in any individual, you may exclaim—this is a neuropterous insect."[1] The neuropterous species, however, may be readily distinguished from the orthopterous and hemipterous kinds by the greater difference of consistence in the two latter between the upper and under wings. The Hymenoptera, again, have generally much longer maxillæ—serving rather to suck the juices than to bruise the more solid portions of the substances on which they feed. The scale-covered wings of the lepidopterous order prevent their being confounded with our present subjects; while the Diptera are easily distinguished by the absence of the lower wings, and the different structure of the organs of manducation.

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[1] *Traité de la Culture du Nopal*, 2 vols. 8vo, Paris 1787. This author endeavoured to introduce the Spanish American cochineal into St Domingo, but they perished for want of care.

[2] *Annal. des Sciences Nat.* t. viii. p. 105.

[3] We scarcely think that the creature above alluded to can be a caterpillar properly so called, that is, the larva of a lepidopterous insect.

[4] ODONATA, and the majority of SYNISTATA, of Fabricius.

The mouth in the neuropterous order is generally composed of a labrum and a labium, of two mandibles, and a pair of maxillæ. The latter organs are very sharp and strong among the *Libellulæ*, which prey on other insects, but extremely small or almost imperceptible in the *Ephemeræ*, which, as their name implies, are very short-lived, and take no nourishment in the perfect state. The palpi are very short in the former tribes, but exceedingly long among the *Myrmeleones*. Although the antennæ, in the majority, are filiform or setaceous, they are terminated by an elongated club in those last named; while in the genus *Ascalaphus* they are very long and slender, and terminate in a little button, resembling those of many Lepidoptera. The wings are sometimes tectiform or incumbent, sometimes stretched out horizontally. Though frequently alike in size, they occasionally differ from each other. Thus in the genus *Nemoptera* the under pair are very long and narrow, while in some Ephemeræ they are almost obliterated.

In the larva and nympha states these insects are either terrestrial or aquatic, according to their kinds. In the former case some dwell beneath the bark of trees, others move about on twigs and branches, making an unresisting prey of Aphides; while a certain number inhabit sandy soils, where they excavate insidious pit-falls, and seize upon whatever insects venture within the circle of their treacherous toils. The aquatic species dwell in their earlier states in ponds and marshes, and in the shallower and more sheltered parts of lakes and rivers. They then respire by means of organs which exhibit a strong analogy to the gills of fishes, but which Latreille recognises only as exterior tracheal appendages, named false branchia. Many construct very ingenious cases of small stones, shells, and twigs of water-plants, in which they move about in their watery element.

The Neuroptera are, in general, insects of an extremely elegant deportment. They fly with great facility, and are not unfrequently adorned by agreeable and varied colours. Though almost all carnivorous as larvæ, their habits differ greatly in the perfect state. Some undergo a semi-metamorphosis,—others are completely changed,—but all the larvæ are provided with six-hooked feet, which they usually employ in their search for food. Latreille divides the order into three families, which present the following succession of natural affinities. 1*st*, Carnivorous insects, subject to a semi-metamorphosis, with aquatic larvæ; 2*d*, carnivorous insects, subject to a complete metamorphosis, with terrestrial or aquatic larvæ; 3*d*, carnivorous or omnivorous insects, terrestrial, with semi-metamorphosis; 4*th*, herbivorous insects, subject to a complete metamorphosis, with aquatic larvæ, which construct portable domicils. He terminates with such as have the wings the least reticulated, and which bear a resemblance to Phalenæ or Tineites.

FAMILY I.—SUBULICORNES, Lat.

These consist of the *Odonata* of Fabricius, and the genus *Ephemera*. The antennæ are subulate or awl-shaped, scarcely longer than the head, and consist at most of seven articulations, of which the last is setiform. The mandibles and maxillæ are entirely covered by the labrum and labium, or by the anterior or prolonged portion of the head. The wings are always much reticulated, separate, sometimes horizontal, sometimes raised perpendicularly. The inferior pair, though often as large as the superior, are in some instances much less, or even entirely wanting. The real eyes are large and projecting, and have from two to three stemmatic eyes placed between them. They feed on living prey, and pass their earlier states beneath the waters. The larvæ and nymphs exhibit a form somewhat similar to that of the perfect insects, and respire by particular organs placed along the sides or at least the extremity of the abdomen. They creep up the stalks of plants, or otherwise leave their moist abodes, before undergoing their final transformation.

In the great genus Libellula of Linn. (Plate CCXXX. figs. 1, 2, 3, 4, 6), the mandibles and maxillæ are corneous and very strong, and are covered by the labrum above and by the labium below. The tarsi have three articulations. The wings are nearly of equal size, and the posterior extremity of the body is terminated simply by hooks or by foliaceous appendages.

The light and graceful form of these insects, their beautiful and varied colours, their large and lustrous wings, and the hawk-like velocity with which they pursue their flying prey, render them objects of our frequent attention, and easy to be recognised. Our present observations apply to all the component parts of the great and unrestricted genus just named. We shall afterwards give the specialities of the minor groups. The eyes of the Libellulæ, or dragon-flies in general, are large and lateral; the stemmata are placed upon the vertex. The antennæ are inserted on the front, behind a vesicular elevation, and are composed in the greater number of from five to six articulations, or at least of three, of which the last is composite, and attenuated in the form of a style. The labrum is arched and semicircular; the mandibles are of a scaly texture, very strong and toothed; the maxillæ are terminated by a piece of the same consistence, dentated, spinous, and ciliated on the inner side, with a palpus of one articulation on its back, representing what is called the *galea* in the orthopterous tribes. The labium is large, arched, and trifoliate, the two lateral foliæ being in fact palpi. There exists a kind of epiglottis, or vesicular and longitudinal tongue, in the interior of the mouth. The abdomen, always considerably elongated, varies in its contour, being in some cylindrical, in others compressed, and occasionally flattened. It is terminated in the males by two lamellar appendages, which likewise vary in form according to the species. The legs are short, and directed forwards. "Le dessous du second anneau de l'abdo-

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[1] *Introduc. to Ent.* vol. iv. p. 371.

men renferme, dans les mâles, leurs organs sexuels, et, comme ceux de la femélle sont situés au dernier anneau, l'accouplement de ces insectes s'opère différemment que dans les autres. Le mâle, planant d'abord au-dessus de sa femélle, la saisait par le col, au moyen des crochets de l'extrêmité postérieure de son ventre, et s'envole ainsi avec elle. Au bout d'un temps, plus ou moins long, celle-ci se pretant a ces desirs, courbe en dessous son abdomen, et en applique l'extrêmité sur les parties du mâle, dont le corps est alors courbé en forme de boucle. La copulation a souvent lieu dans les airs, et quelquefois encore sur les corps où ces insectes sont posés."[1] The female deposits her eggs on aquatic plants, by plunging her posterior extremity beneath the water.

The larvæ and nymphs are aquatic. The former have no wings, the latter exhibit them in a rudimentary state (Plate CCXXX. figs. 1, 3). The head in these early stages is remarkable for the singular piece which corresponds to the labium. It assumes the form of a mask, and covers the mandibles, the maxillæ, and almost all the under parts of the head. It is composed of, 1*st*, a principal triangular piece, sometimes arched, sometimes flat, named *mentonnière* (or chin-cloth) by Réaumur, which articulates by means of a hinge with a pedicle or kind of handle attached to the head; 2*d*, of two other pieces inserted at the lateral and inferior angles of the preceding, moveable at their base, transverse, and either in the form of wide and dentated plates, resembling shutters in their nature, and the mode in which they close the mouth, or analogous to little hooks or claws. To that portion of the mask where the *mentonnière* is articulated with its pedicle, or the knee, and which appears to terminate it inferiorly when the mask is bent or folded upon itself, Réaumur applied the term *mentum*. The insect unfolds and extends this peculiar apparatus with great promptitude, and seizes its prey with the pincers of the superior portion. These creatures live for ten or eleven months in the water, during which period they several times cast their skin. When the nymphs are ready to assume their final change, the form and position of the wing-cases undergo an alteration. They then leave the water, become dry and crisp, the skin of the thorax bursts asunder, and the winged insect issues forth under a different and much more ornamental aspect. The name of *Demoiselles*, by which many of them are known to our continental neighbours, attests the impression produced by their graceful forms or elegant movements. These Demoiselles always come out of the water head foremost; but no sooner have they burst their casements than they turn themselves round, and hang for a time with their head downward, being prevented from falling by the hinder segments of the abdomen being still entangled in and adhering to the skin of the nymph. After a time the young aspirant again turns round, and seizing the anterior portion of the cloven skin with its claws, it finally succeeds in dragging itself forth from its former dwelling. The wings, however, are as yet narrow, thick, and closely folded, just like a leaf during the bursting spring. After another hour or two they become firm, consistent, and extended both in length and breadth, and the gay and gorgeous creature, launching buoyantly into the air, becomes the tyrant of the insect world.

M. Poe, who paid particular attention to the entomology of Cuba, informed Latreille that, at a certain season of the year, the northern winds sweep an innumerable host of a species of dragon-fly into Havannah and its environs.[2]

The Linnæan genus LIBELLULA is now divided into three.[3] In LIBELLULA[4] proper (Plate CCXXX. fig. 2), the wings are extended horizontally in repose, the head is almost globular, with the eyes contiguous or approximate. There is a vesicular elevation, with a stemmatic eye on each side upon the vertex; the other stemmatic eye is larger, and placed anteriorly. The central division of the labium is much smaller than the lateral ones, which unite above by a longitudinal suture, and exactly close the mouth. The abdomen is usually ensiform, and flattened. The larvæ and nymphs (ibid. fig. 1) have five appendages to the posterior extremity of the abdomen, which combine to form a pointed tail; their body is short, and the part named *mentonnière* by Réaumur is arched in the form of a helmet, with the two lateral pieces in the form of shutters. We may mention *L. depressa*, Linn. (the species figured), as a British example of the genus. In ÆSHNA, Fab. the species resemble the preceding in the position of the wings and the form of the head, but the posterior stemmatic eyes are placed upon a simple transverse elevation or keel. The intermediate lobe of the labium is also larger, and the other two are distant, and armed with a very strong tooth, and a spinous appendage. The abdomen is always narrow and elongated. The form of the larvæ and nymphs is also more lengthened than that of the same states in Libellulæ. The mask is flat, and the two pincers are narrow, with a moveable nail at the end. The abdomen, in their early states, is also terminated by five appendages, one of which, however, is truncated at the point. *L. grandis*, Linn. the largest and one of the swiftest and most powerful and predaceous of the British species, belongs to this genus. In AGRION,[5] Fab. (Plate CCXXX. fig. 6), the wings are held perpendicularly in repose, the head is transversal, and the eyes distant. The form of the labium is analogous to that of Æshna, but the middle lobe is divided into two as far as its base. The third joint of the lateral lobes is in the form of a membranous ligula. The antennæ seem to be composed of only four joints. The front presents no vesicle, and the stemmatic eyes are of nearly equal size, and disposed triangularly on the vertex. The abdomen is very slender or even filiform, and, in some foreign species, of extraordinary length. That of the female is furnished with serrated laminæ at its posterior extremity. The form of the body in the larva and nympha states of this genus is likewise long and slender, and the abdomen is terminated by three fin-like plates (ibid. fig. 3). The mask is flat, the upper extremity of the *mentonnière* being raised to a point in some, and forked or sloped in others; the pincers are narrow, but terminate in several dentations resembling hands. The species are very numerous. *A. virgo* has dark-coloured wings, and a lustrous metallic body, varying from golden green to greenish blue. Its flight is irregular and rather heavy. To this genus also belong the small pale-coloured kinds, annulated with black, and presenting a considerable range of variation even among individuals of the same species, besides the more fixed distinctions of a sexual character.

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[1] *Règne Animal*, t. v. p. 237.

[2] *Ibid.* t. v. p. 238.

[3] The structure of the eyes in dragon-flies is described by Cuvier in the *Mém. de la Soc. d'Hist. Nat. de Paris*, t. i. In addition to the ordinary systematic works, the student of the species should attend particularly to a monograph on European Libellulæ, published in the *Horæ Entomologicæ* of M. Toussaint de Charpentier, another monograph on the same by M. Vander Linden, and a memoir by the latter author on the species which occur in the territory of Bologna.

[4] Named probably from the Latin *Libellus*, a little book, on account of the page-like expansion of the wings.

[5] From ἄγριος, *cruel* or *ferocious*.

In the other Neuroptera of the family Subulicornes the mouth is entirely membranous or very soft, and composed of not very distinguishable parts. Their tarsi consist of five joints. The inferior wings are much smaller than the upper ones, and are even sometimes wanting. The abdomen is terminated by two or three setæ. They form the old genus EPHEMERA[1] of Linn., Plate CCXXX. figs. 5, 7, and 9.

In these frail and fleeting insects the body is very soft, long, and tapering, and terminates as above mentioned. Their antennæ are very small, and composed of three articulations, of which the last is very long, and in the form of a conical thread. The anterior portion of their head projects in the manner of a clypeus, is frequently carinated and emarginate, and covers the mouth, of which it is difficult to distinguish the structure, on account of the slight development of its parts, and the softness of their texture. The Ephemeræ in repose carry their wings almost always in a perpendicular position, or a little inclined backwards. The legs are slender, with very short tibiæ, frequently confounded with the tarsi, which often exhibit only four joints, owing to the evanescence of the first; the two hooks of the last are much compressed into the form of a little pallet. The two anterior legs are much longer than the others, inserted almost beneath the head, and extended forwards. These insects usually make their appearance in the winged state towards the evening in fine summer weather, and sometimes in such abundance, that in certain districts of France cart-loads of them have been gathered from the ground, and employed as manure. *E. albipennis*, in particular, a species, as its name implies, remarkable for the whiteness of its wings, sometimes rises and falls in such quantities by the banks of rivers, as to thicken the air and whiten the surface of the ground,—reminding one, even in the verdurous and leafy summer, of

> The flaky weight of winter's purest snows.

The males are distinguished from the females by a pair of articulated hooks, and their fore legs and caudal appendages are likewise longer. Although strictly ephemeral in their final state, they have rather a more extended term of life than usual in their subaqueous abodes, where they are said to live and prosper for two or three years. In the larva state the antennæ are longer than afterwards; the stemmatic eyes are wanting; the mouth presents two horn-like projections, which are regarded as mandibles; the abdomen is furnished on each side with a range of laminæ or leaflets, usually united at the base in pairs. These last-named parts are a kind of false branchia, on which the tracheal ramifications are extended, and which serve not only for the purposes of respiration, but also for those of locomotion. The tarsi have only a single hook at their extremity. The abdomen is terminated by setæ, of the same amount as in the perfect insect. The nymphs differ from the larvæ chiefly in being possessed of little sheaths or wing-cases (Plate CCXXX. fig. 10). When *ripe*, they leave the waters, and undergo their final transformation, pretty much after the manner of the Libellulæ already described, although more rapidly. One singular characteristic, however, attends their winged condition, from which the other tribes are free; they cast off a complete envelope or skin, including that even of the limbs, setæ, and antennæ, almost immediately after they have attained the perfect state, or at least what Mr Curtis has well named the *pseudo-imago*. While following the delightful pursuit of angling, both along our own unrivalled streams, and by the banks of foreign waters, we have frequently had our fishing panier and the rims of our hat covered by a pearly layer of these ghost-like exuviæ, and it proved extremely interesting to witness what we had often previously perused in the accurate pages of Réaumur. Swammerdam, who had long ago observed and described this singular moulting, seems to think that the male sex is alone subjected to it. The manners and metamorphosis of these insects have been minutely detailed by the laborious author just named, in his *Biblia Naturæ*, as well as by Réaumur and Degeer, in their respective *Mémoires* on the natural history of insects. The angler recognises them under the name of May-flies,—an imitation of which, during the early part of the trouting season, is deemed a lure not to be resisted by the finny race. We cannot here describe the species in detail. We have figured several different kinds on Plate CCXXX. Some have four wings, figs. 5 and 9; others have only two, fig. 7. Of the latter the eyes are sometimes very singularly constructed, being double, or two on each side, one above the other, as shown by fig. 8 of the same plate.

FAMILY II.—PLANIPENNES.

Latreille here includes those neuropterous species of which the antennæ, always composed of a great number of articulations, are considerably longer than the head, without being styliform or awl-shaped. The mandibles are very distinct, and the under wings, almost equal to the superior ones, are extended, or simply folded beneath at their inner margin. The wings are very generally much reticulated and naked, with the maxillary palpi for the most part filiform, or a little larger at the extremity, shorter than the head, and composed of from four to five articulations. These insects are divisible into five sections, which compose, in relation to their natural habits, an equal number of small sub-families, as follows.

SECTION 1ST, PANORPATÆ.

Characterized by five articulations to all the tarsi, and by having the anterior extremity of the head prolonged and narrowed, in the form of a beak or proboscis. These constitute the old genus *Panorpa* of Linn., commonly called scorpion-flies, probably from the peculiar turning up of their tails (Plate CCXXX. figs. 13 and 20). The antennæ are setaceous and inserted between the eyes. The clypeus is prolonged into a corneous lamina, arched beneath for the reception of the mouth. The mandibles, maxillæ, and labium, are almost linear (Plate CCXXX. fig. 16). The palpi, varying in number from four to six, are filiform; those of the maxillæ do not distinctly present more than four joints. The body is elongated, the head vertical, the first segment of the thorax usually very small, and in the form of a collar. The abdomen is conical or almost cylindrical. In several species the sexes are very dissimilar. Naturalists do not as yet appear to have acquired any knowledge of their transformations. They are now divided into the following genera: NEMOPTERA,[2] (Plate CCXXX. fig. 11), BITTACUS, PANORPA proper (ibid. fig. 13), and BOREUS. The type of the last-named genus, and the only species known, is the *Panorpa hyemalis* of Linn. a small insect scarcely a line in length, of a cupreous black colour. It lives among moss in the northern parts of Europe, and is also found in the Alps, not far from the region of perpetual snow.

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[1] Named, in allusion to the seeming shortness of their lives, from εφημερος, *that which lasts a day.*

[2] From νημα, *a thread*, and πτερα, *wings.*

SECTION 2D, MYRMELEONIDES, Lat.

These are also characterized by five articulations to all the tarsi; but they differ from the preceding in not having the head prolonged in the form of a beak or proboscis. The antennæ are gradually enlarged, or have a globular or button-like termination. The head is transverse, vertical, and exhibits no stemmatic eyes. The ordinary organs of vision are round and projecting. The mouth is furnished with six palpi, of which the labial are usually longer than the others, and somewhat inflated at the extremity. The palate of the mouth is raised in the form of an epiglottis. The first segment of the thorax is small. The wings are equal, elongated, tectiform, or incumbent. The abdomen is generally long and cylindrical, with two projecting appendages at the extremity in the male sex. The legs are short.

These insects affect warm places, and are consequently more frequent in the southern countries of Europe than in the chilly regions of the north. They rest on plants, and generally remain quiescent during the day. The nymphs are inactive; but the generality of the perfect insects are well endowed with the power of flight. They form the old genus *Myrmeleon* of Linn., which Fabricius and Latreille have divided into two.

In MYRMELEON[1] proper (Plate CCXXX. fig. 12), the antennæ are short, gradually thickened or almost fusiform, and hooked at the extremity. The abdomen is long and linear. The singular larva of one of these insects (ibid. fig. 14) has been attentively studied by Poupart, Vallisnieri, Roesel, Réaumur, and others. It is rather more than half an inch in length, of an oval depressed form and greyish colour. It feeds chiefly on Solomon's emblem of industry, and has hence received the name of *Formica-Leo* or lion-ant. Its head is very small, but armed with two strong and lengthened mandibles, serrated on the inner side, and pointed at the end. These parts look rather like a pair of horns than organs of manducation; but it is with them that the larva seizes upon its prey; and as they are pierced at the extremity, they no doubt also act as suckers. As its form does not admit of active locomotion, nature has made amends by endowing this insect with admirable instinctive skill and cunning. It constructs, in a dry or sandy soil, a funnel-shaped excavation, the sides and edges of which are loose and crumbling, and at the bottom of which, with body closely covered, but with ever-ready jaws projecting upwards, the insidious larva lies concealed. No sooner does an industrious ant, laden perhaps with its republican provision, approach the edge of the unsuspected slope, to it as dangerous as a volcanic crater or avalanche of snow, than the finely poised sand immediately gives way, and the persevering citizen, rolling to the bottom, is instantly seized and sucked to a shadow by the lurking tyrant. The dead body is ere long tossed by a jerk of the head beyond the immediate boundaries of the dwelling, probably because it is by this time useless, or, as some French naturalist has expressed it, "pour que son cadavre n'épouvante pas les autres fourmis qu'il attend." There are tartars, however, among Myrmeleons as well as men; and it sometimes happens that a large and vigorous winged insect, such as a wasp, bee, or beetle, tumbles head foremost into the pit. "When Greek meets Greek, then comes the tug of war;" and when a lion-ant has the tail of a wasp in his mouth, there is no saying exactly how the combat may end. The one is furnished with jaws tenacious as well as strong,—but he bears no "charmed life;" while the other is armed with a weapon which the dews of heaven cannot rust, and compared with the keenness of which the brightest sword in Damascus is as a broken foil. In these doubtful, though, to one or other of the parties, eventually disastrous circumstances, the result at last is, that either the lion-ant is dragged out of his den and stung to death, or dropped upon the ground and left a prey to birds, or that the winged insect is maimed, disabled, drawn into the sand, and slain. If an insect incapable of flight, or from its situation unable to use its wings, but of larger size than the Myrmeleon deems it prudent at once to seize upon, chances to fall into the snare, it is overwhelmed in its attempts to re-ascend, by repeated showers of sand, which its enemy directs upon it with unerring aim. No sooner, however, is the strength of the toiling and exasperated Sisyphus at least in part exhausted, than he too is seized upon, and sucked to death. The lion-ant makes use of its head as a catapult or instrument of war, with which to shower the sand upon its astonished prey. This singular larva is capable of enduring a very long-continued fast. When it has attained to the natural term of its increase, which requires the lapse, it is said, of nearly a couple of years, it weaves a white cocoon, by means of two spinners placed at the posterior extremity of the body, of a rounded form and satin lustre, but covered with grains of sand. In this it undergoes its transformation to the nympha state (Plate CCXXX. fig. 15). The perfect insect bursts from its silken tomb in the course of from fifteen to twenty days. We are acquainted with many species of the genus. Besides the one of which we have just now sketched the history, and which is the *Myrmeleon formicarium* of systematic writers, another noted species, named *M. Libelluloides*, occurs in the south of France. It is a very large insect, measuring from four to five inches between the tips of the extended wings, and was described as a *Hemerobius* by Linnæus. It is the *Libella turcica* of old Petiver, and the *Musca rarissima* of Ray. We were once nearly drowned in trying to capture it by the side of a muddy stream. The flight of both of these insects, and of all belonging to the genus, is slow and heavy. They seldom fly far, and seem to end their lives near the places where they had their birth,—even to the last "loving the spots which once they gloried in." They are unknown in Britain.[2]

In the genus ASCALAPHUS,[3] Fab. (Plate CCXXX. fig. 19), the antennæ are very long, and terminate somewhat abruptly in a club or expansion. The wings are proportionably broader than those of Myrmeleon. The flight of these insects is rapid and light. They occur chiefly in the warmer parts of Africa and America, although a few are found in Europe. Of these *A. Italicus* occurs in France as far north as the environs of Fontainebleau. We have no very precise knowledge of their transformations. They do not occur in Britain.

SECTION 3D, HEMEROBINI.

The component parts of this group resemble those of the preceding in the general form of the body and wings; but the antennæ are filiform, and the palpi only four in number. They form the old genus *Hemerobius* of Linn. and Fab. which has since been subdivided as follows:—

In HEMEROBIUS proper (of Lat.) the first segment of the thorax is very small, the wings incumbent, and the last article of the palpi is the thickest, ovoid, and pointed.

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[1] From *μυϱμεξ*, *an ant*, and *λεον*, *a lion*.

[2] *M. formicarium* holds a *nominal* place as a British insect; but we have never felt *assured* of its existence as an indigenous species.

[3] Ασκαλαφος is the ancient mythological name of a bird. We do not know for what reason it was applied to the above genus.

The larvæ are terrestrial, that is, not aquatic. They wander about from place to place, committing great havoc among Aphides, their favourite food,—for which reason they are named *lions des pucerons* by Réaumur. These they seize by means of their horn-like mandibles, and speedily suck to death. Some of the perfect insects are exceedingly beautiful, especially a well-known British species called *Hemerobius perla*, which is of a pale yellowish green, with delicately transparent yet lustrous wings, and brilliant golden eyes. Its flight is feeble. The females lay their eggs on leaves, to the number of twelve or sixteen in a group. They are whitish and oval, and are supported and secured by a long hair-like stalk or pedicle, which some botanists, less versed in edible fungi than Dr Greville, have mistaken for a species of *mushroom!* (See Plate CCXXX. fig. 21.)

Other allied species have the first segment of the thorax large, with the wings usually placed upon the body in a horizontal position. The palpi are filiform, with the last article conical, or almost cylindrical, and frequently shorter than the preceding. The larvæ are aquatic. These insects were placed by Fabricius, along with the species of the genus *Perla* of Geoffroy (from which, however, they differ in the number of articulations of the tarsi), under the genus SEMBLIS, which is itself composed of CORYDALIS, CHAULIODES, and SIALIS, of Latreille.[1]

SECTION 4TH, TERMITINÆ.

This group comprises such Neuroptera as are subject to a semi-metamorphosis, and are active and carnivorous, or rather omnivorous gnawers, in all their states. With the exception of the Mantispæ, which, in regard to their anterior legs, resembling those of the Mantides, are peculiar in their order,—the tarsi have at most four articulations, in which they differ from the preceding genera of the family with which we are still engaged. The mandibles are always corneous and strong.

Some possess tarsi consisting of from five to three articulations, with very distinct and projecting labial palpi. The antennæ are generally composed of more than ten joints, the prothorax is large, in the form of a corselet, and the wings are of equal size, and much reticulated.

In the genus MANTISPA of Illiger (*Rhaphidia*, Scopoli, Linn.; *Mantis*, Fab. Oliv.), all the tarsi have five articulations, and the anterior legs, like those of Mantis, are adapted for prehension. The antennæ are very short and granose, the eyes large, the prothorax very long, thickened anteriorly, and the wings incumbent. This genus consists of not more than five or six species, only one of which, *M. pagana*, is found in Europe. In the genus RAPHIDIA,[2] Linn. Fab. (Plate CCXXX. fig. 24), the tarsi have only four articulations. The wings are incumbent when at rest, the head elongated, and narrowed posteriorly, the thorax long, narrow, and almost cylindrical. The abdomen of the female is terminated by a long exterior oviduct, formed by a couple of laminæ. The species figured on the plate referred to is well known in Britain. It lives in woods. Both the larva and imago feed on other insects. The former is lively in its movements when disturbed. It lives in the fissures of trees, and has the form of a little serpent. In the genus TERMES, which contains the famous white ant (Plate CCXXX. figs. 17, 18, and 23), the tarsi are likewise composed of four joints, but the wings are very long, and are horizontally spread upon the body. The head is rounded, and the thorax almost square or semicircular. The body of these insects is depressed, and the antennæ, at least in the females, are short, and formed like a chaplet. The mouth resembles that of the orthopterous order, and the labium is quadrifid. There are three ocelli, one of which, placed upon the front, is indistinct, and the other two are placed laterally, near the internal margin of the ordinary eyes. The wings are usually rather transparent, colourless, with fine and close-set nervures, but not very distinctly reticulated. There are two small conical biarticulated points at the extremity of the abdomen. The legs are short. A good monograph of this singular and destructive genus is still a desideratum in Entomology. Several species, inhabiting widely distant countries, have been described under the general name of *Termes fatale*, but we have still an insufficient knowledge of their actual and distinguishing characteristics. So confused was the acquaintance of our immediate predecessors with these insects, that the larvæ of *T. flavicolle*, Fab. were placed by Linnæus among his *Aptera*, while the perfect insects formed a part of his genus *Hemerobius*. These Termites are for the most part peculiar to countries placed between or near the tropics. The individuals named neuters or labourers among the white ants (commonly so called) are the wingless larvæ (fig. 17), and in that state their powers of destruction are quite appalling. They live together in assemblages so vast as almost to defy calculation, and excavate galleries under ground, in trees, tables and all kinds of furniture, as well as in the timber of dwelling-houses. Dr M'Murtrie saw a beautiful edifice in the Isle of France that had been abandoned within a few months after its completion, on account of the attacks of these destructive creatures. The whole building was a mere shell.[3] Whatever ligneous bodies are mined by them, retaining little but a superficial bark, soon crumble into dust; and where the roof of a house, or heavy lintel stone, depends on such support, the insecurity may be as easily imagined as described. They sometimes construct external tunnels or covered ways, which conceal them from view while passing to and from their subterranean dwellings. Sometimes their habitations are raised pyramidally above the surface, in other instances they resemble turrets, with an eave-like expansion on the top. Some are broader and extremely solid; and when constructed, as they often are, in groups, they exhibit the appearance of a little village. They are so strongly built, that when raised to only half their height, they are capable of supporting such wild bulls as mount upon them to act as sentinels while the rest of the flock is feeding. When at their full height of ten or twelve feet, they are used by men as stations from which to look across the country, the grass itself being in those regions of equal height. Smeathman, to whom we owe a curious and often-quoted narrative of their history, has frequently stood with four companions on the top of one of their buildings, employing it as a watch-tower by the shore, from which to obtain sight of whatever vessels might heave in sight. Besides the larvæ or workers, we find another set of inhabitants, of which the nature is not yet clearly known, although their functions are obvious. They are known by the name of soldiers or neuters, and were erroneously regarded by Fabricius as the nymphs. They defend the habitation. When a breach is effected with a pick-axe, they make their appearance, and snap about in all directions with their mandibles,—apparently in a state of considerable indignation. When the attack has ceased, the soldiers retire, and are succeeded by the labourers, who speedily repair the breach. They are still attended, however, by a few soldiers, who seem to act as superintendents of the work. The nymphs bear the rudiments of wings; in other respects they resemble the larvæ. No sooner do they become perfect, by acquiring the organs of flight, than they wing their way from their original dwellings, during the evening, or the stillness of night, and in incalculable numbers. At sunrise, however, by a singular law of nature, they lose their wings, which dry up, become shrivelled, and fall to the ground. In this defenceless state they become the prey of many reptiles, and of insect-eating birds. Indeed they seem not to be despised in that respect even by man himself; for not only are they greedily devoured by Hottentots and negroes, but have been often eaten by Europeans with delight. Mr Smeathman found them " delicate, nourishing, and wholesome, without sauce or other help from cookery, than merely roasting them in the manner of coffee." He indeed discoursed with various friends on the taste of white ants, and on comparing notes, they agreed that these insects were " delicious and delicate eating." One gentleman compared them to sugared marrow, while another thought they tasted like " sugared cream and a paste of sweet almonds."[1] Although prodigious numbers perish in consequence of this migratory instinct, such are their vast powers of fecundity, that old colonies are soon replenished, or new ones formed. According to Smeathman, the provident larvæ seize upon all the winged couples they can find, and shut them up in a roomy cell or nuptial chamber, where they supply them with abundant food; " mais j'ai lieu de présumer," says Latreille, " que l'accouplement a lieu, comme celui des fourmis, dans l'air ou hors de l'habitation, et que les femelles occupent seules l'attention des larves, dans le but de former une nouvelle colonie." The abdomen of the pregnant female (Plate CCXXX. fig. 23) becomes so greatly dilated as to exceed the rest of her body by 1500 or 2000 times, and she is then about a thousand times heavier than her husband. Indeed well she may, if, as is reported, she is endowed with the power of laying *thirty-one million five hundred and thirty-six thousand* eggs in the course of a year. Those fond of arithmetic may try to discover how many grandchildren she is likely to possess by the termination of the ensuing season.

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[1] See *Règne Animal*, t. v. p. 252.

[2] From ῥαφις ιδος, *a needle*.

[3] Cuvier's *Animal Kingdom*, American edition, vol. iv. p. 73.

Certain Termites (*T. arborum*) live on trees, where they build nests as large as sugar casks, and from seventy to eighty feet above the ground. These are formed of particles of gnawed wood cemented by a gluten either secreted by themselves, as silk is by caterpillars, or gathered from gummiferous trees. They are so strongly attached to their supporting branches as to resist the violence even of those tornadoes which so often in tropical countries level alike the palaces of kings, and " huts where poor men lie." Indeed they cannot be detached except by being hewn in pieces. The genus Termes is not unknown in Europe. *T. lucifugum* of Rossi (*Faun. Etrusc.*) occurs in the southern provinces of France, where it dwells in the interior of various trees. It has so greatly multiplied in the workshops and storehouses of the navy-yard of Rochefort that it cannot be extirpated, and is the cause of constant damage. *T. flavicolle* proves extremely injurious to the olive trees in Spain. Our " favoured isle" is fortunately free from these and many other continental pests,—if an entomologist may so express himself regarding species which would no doubt be highly prized *as British* by many a fond collector.

The remaining Termitinæ are characterized by their biarticulate tarsi, and their short and indistinct labial palpi. The antennæ consist of about ten joints; the anterior segment of the thorax is very small; and the inferior wings are less than the superior. They form the genus Psocus of Latreille, which consists of very small species with short soft bodies, often hunched or inflated, with a large head, setaceous antennæ, projecting maxillary palpi, and incumbent wings, slightly reticulated or but simply veined. These are active insects, living beneath the bark of trees, in wood, straw, &c. Some occur among books and in collections of plants and insects. They seem peculiar to Europe. *P. pulsatorius* derives its name from the sound, resembling the ticking of a watch, which, in common with some other insects, it utters in our apartments. Its anatomy is described by Germar.[2] We have many British species.

SECTION 5TH, PERLIDES.

Of these the tarsi are furnished with three articulations, and the mandibles are almost always partly membranous and small, with the inferior wings wider than the superior, and doubled on themselves at their inner edge. The genera are PERLA of Geoffroy, and NEMOURA[3] of Latreille (*Phryganea*, Linn.).[4]

FAMILY III.—PLICIPENNES.

The insects of this family have no perceptible mandibles. Their inferior wings are usually broader than the upper ones, and longitudinally plaited. They compose the genus PHRYGANEA[5] of Linn. divided by Latreille into SERICOSTOMA[6] and PHRYGANEA proper (see Plate CCXXX. fig. 26). In the larva state (figs. 22 and 25) they live in tubes or cases of their own construction, made of a great variety of substances, according to the species. Latreille regards them as simply herbivorous, although other authors maintain that, in addition to aquatic plants, they prey upon the larvæ of gnats and dragon-flies.

We shall conclude our sketch of this order by observing that the characters and habits of the genus PHRYGANEA being very peculiar, the species have in recent times been separated from the neuropterous tribes, and erected into an additional order, TRICHOPTERA, Kirby, so called from ϑϱιξ, τϱιχος, *hair*, in allusion to the usual roughness of the wings. Both Réaumur and Degeer had previously observed that they were allied to the lepidopterous order. " Although some other insects," Mr Kirby has remarked, " (*Myrmeleon* and *Hemerobius*), placed in the *Neuroptera*, do not agree with the rest in their metamorphosis, yet in their perfect state they exhibit the principal characters of the order, and therefore are properly retained in it; but *Phryganea* differs from the rest both in metamorphosis and characters. Its metamorphosis is very peculiar, the larva imitating many of the *Tineæ*, in constructing, of various materials, a kind of case for its habitation, from which circumstance they are commonly called *case-worms;* and the pupa, which is *incomplete*, and at first quiescent, just before its final change, by a wonderful provision of an all-wise Creator, becomes locomotive, that it may place itself in a situation of security out of the water before it casts its exuviæ; and for this purpose the antennæ and the four anterior legs are not confined under the general envelope, though each has its peculiar integument, so that the animal can use them when the time comes for it to emerge from the water, and commence a denizen of the air. The imago exhibits few or none of the characters of the other *neuropterous* genera. The wings are veined in a peculiar manner, without reticulations, in some degree like those of *Lepidoptera*. The antennæ resemble much those of the Tinea tribe, and the tibiæ of many of them are armed with the two pair of spurs observable in so many of the moths; but they have no spiral tongue, the wings, though hairy, have no scales, the under wings are folded longitudinally, and the head, besides the usual compound eyes, has three stemmata. If these remarks appear to entomologists well founded, and it be thought right to consider *Phryganea* as constituting a new order, I think it might be distinguished, since the names of all the known species are hairy, by the name of *Trichoptera*."[1]

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[1] *Phil. Trans.* vol. lxxi. p. 169, note. The reader will find a good summary of their history in a more accessible work, " Insect Architecture," in the *Library of Entertaining Knowledge.*

[2] *Magazin der Entomologie*, vol. iv.

[3] From *νιμα, a thread*, and *οὐϱὰ, tail.*

[4] See *Gen. Crust. et Insect.* t. iii. p. 210; *Règne Animal*, t. v. p. 258; *Encyclop. Méth.* art. NEMOURE; and *Mémoire sur les Larves de Nemoures*, par F. T. Pictet, in the *Ann. des Sciences Nat.* t. xxvi. p. 369.

[5] From *φϱυγανιον, a faggot*, in allusion, we presume, to the usual aspect of their dwellings while aquatic larvæ.

[6] From *σηϱικον, silk*, and *στόμα, the mouth.*

ORDER V.—HYMENOPTERA.[2]

This order, of more direct utility to man than many others, in as far as it contains the species which yield us wax and honey, is characterized, like the preceding one, by the possession of four membranous and naked wings. The mouth consists of mandibles, maxillæ, and an under and an upper lip. The organs of flight, however, differ from those of the Neuroptera, in being simply veined rather than reticulated; and the upper wings are always somewhat larger than the under pair. The abdomen of the female is terminated either by an ovipositor or sting. Besides the ordinary visual organs, these insects are all provided with three small stemmatic eyes. The antennæ are variable, not only in different genera, but in different sexes of the same species. In the majority, however, they are filiform or setaceous. The maxillæ and the labium are generally long and narrow, fixed in a deep cavity of the head by lengthened muscles, semi-tubular at their lower portion, often folded at their extremity, and serving rather for the transmission of nutritive juices than for mastication properly so called. Indeed in several these parts unite to form a kind of trunk or sucker. The ligula is membranous, whether widened at the extremity, or long and filiform, with the pharynx at its anterior base, and frequently covered by a kind of sub-labrum or epipharynx. The palpi are four in number, two labial and two maxillary. The thorax as usual consists of three segments, of which the foremost is very short, and the two remainder are intimately united. The wings cross each other horizontally over the body, and the upper pair have a little rounded convex knob at their base. The abdomen is composed of from five to nine segments, the number being frequently six in the females and seven in the males. It is usually suspended, as it were, to the thorax by a small and slender pedicle; in which case its second articulation seems to be the first, the latter being in fact confounded with the metathorax. The ovipositor and the sting (both being constructed on the same model) are composed, in the generality, of three long and slender pieces, two of which serve as a sheath for the third, which is itself, when under the form of a sting, composed of a pair of pieces joined in one. The tarsi are composed of five articulations, none of which is divided.

The structure of the wings of Hymenoptera has served as the basis of a noted method for their classification, made known by M. Jurine.[3] This method is founded on the nature and number of the nervures of the wings, and of the cells or intermediate diaphanous spaces formed by their ramification. The nature of our present treatise, which we have already extended to the proposed limits (and we are still far from our conclusion), will not, however, admit of our entering fully into such details.[4]

The digestive system of Hymenoptera consists in general of two stomachs, of which the second is elongated; of a short intestine, terminated by a widened cloaca; and of numerous biliary vessels, inserted near the pylorus. In regard to their tracheal apparatus, M. Leon Dufour has remarked, that all the Hymenoptera which he has examined exhibit a greater degree of perfection in that part of their structure than any other order of insects. Instead of being composed of cylindrical and elastic vessels, of which the diameter decreases by successive divarications, they present constant dilatations, or determinate vesicles, favourable to the greater or less continuance of air, and capable of being distended or otherwise, accord-

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[1] *Linn. Trans.* xi. p. 87, note.

[2] PIEZATA, Fab.

[3] *Nouvelle Méthode de classer les Hyménoptères et les Diptères*, 1 vol. in 4to, Geneva, 1807. See also, by the same author, *Observations sur les Ailes des Hyménoptères*, in the 24th vol. of the *Mém. de l'Acad. des Sciences de Turin*.

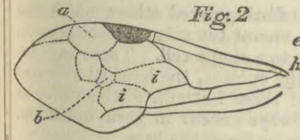
Fig. 2

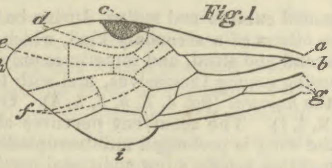
Fig. 1

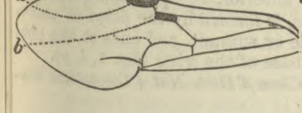
Fig. 3

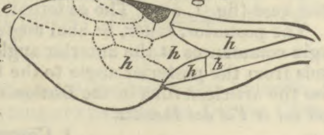
Fig. 4

[4] When we examine a hymenopterous insect with a glass, or even by means of the unaided sight, we shall observe that the external or anterior margin of the upper wings presents two strong approximate parallel nervures, deriving their origin from the thorax, and united by means of a strong expansion of the membrane of the wing. The external nervure is called the *radius*, fig. 1, *a*; the internal the cubitus, fig. 1, *b*. Each of these terminates in a dark-coloured expansion called the stigma, fig. 1, *c*. Besides these larger nervures, which some call *primitive*, several others spring likewise from the base of the wing, and are named *brachial*, fig. 1, *g*. All these principal branches give rise to shorter intersecting nervures, the interlacement of which partitions the wing as it were into membranaceous departments, designated by the name of cells. Several of these, by reason of their constancy of disposition in each genus of hymenopterous insects, have been used with advantage by Jurine for the purposes of classification. A nervure, called the *radial* (fig. 3, *a*), usually springs from the middle of the stigma, and attaining the tip or anterior angle of the wing, leaves between itself and the anterior margin a membranous space, known as the *radial cell* (fig. 4, *a*). If there should, moreover, spring from the stigma a lesser nervure, dividing the cell into two parts, we recognise a pair of radial cells. In this case, however, the larger nervure does not derive its origin from the central line of the stigma, but farther back, or from its basal portion (fig. 1, *d*). It sometimes also happens that the radial nervure, proceeding from the stigma, encounters, before it gains the margin of the wing, a small intersecting nervure, itself proceeding from that margin. The radial cell is then said to be appendaged (*appendicée*), fig. 2, *a*.

Another range of cells, of some importance, has received the name of *cubital* (fig. 1, *e*). It is formed by the posterior edge of the radial nervure, and by another nervure named the *cubital*, which springs from the extremity of the cubitus, near the stigma, and ing to the quantity of their contents. On each side of the base of the abdomen there is a large oval vesicle of the kind alluded to, of a dull milky white, giving rise here and there to radiating bundles of vascular tracheæ, which distribute themselves to the neighbouring organs. On entering the thorax it becomes restricted, is again dilated, and ends insensibly in a tube, of which the subdivisions are lost in the head. Behind these two abdominal vesicles the respiratory organ is prolonged in the shape of two filiform tubes, which give off an infinity of little air-bearing branches, and become confluent towards the anal extremity.[1]

Hymenopterous insects undergo a complete metamorphosis. Most of the larvæ resemble little worms, unprovided with feet. At least those of the second and following families answer that description. Those of the first family, however, have six feet, furnished with hooks; and besides these they frequently possess from twelve to sixteen others of a simply membranous texture. These latter larvæ are named by the French *fausses chenilles.* Both kinds are provided with a scaly head, with mandibles, maxillæ, and a labium, at the extremity of which is a *spinner* for the passage of that silky substance which is ere long employed in the construction of the nymph's cocoon. Some live on vegetable substances; others, and these are the footless or apodal kinds, feed on insects, with which they are supplied by the provident attention of their mothers, which either carry food to their admirably constructed dwellings, or, as among the Ichneumonides, deposit their eggs at once on living larvæ, of which the excluded young soon become the tenacious and destructive parasites. Among bees a vast number of individuals of ambiguous or undeveloped sex are charged, among other arduous labours, with the sustenance of the helpless young, a task performed with a propriety and precision which, with their many additional attributes of instinctive skill, render their proceedings worthy to be classed, if not as standing miracles of nature, at least as deserving the careful contemplation of the wisest minds.

> Happy if full of days—but happier far,
> If, ere we yet discern life's evening star,
> Sick of the service of a world that feeds
> Its patient drudges with dry chaff and weeds,
> We can escape from custom's idiot sway,
> To serve the sovereign we were born to obey.
> More sweet to muse upon his skill display'd
> (Infinite skill) in all that he has made!
> To trace, in nature's most minute design,
> The signature and stamp of power divine,
> Contrivance intricate, express'd with ease,
> Where unassisted sight no beauty sees,
> The shapely limb, the lubricated joint
> Within the small dimensions of a point,
> Muscle and nerve miraculously spun,
> His mighty work, who speaks—and it is done,
> The Invisible in things scarce seen reveal'd,
> To whom an atom is an ample field:
> To wonder at a thousand insect forms,
> These hatch'd, and those resuscitated worms,
> New life ordain'd and brighter scenes to share,
> Once prone on earth, now buoyant upon air,
> Whose shape would make them, had they bulk and size,
> More hideous foes than fancy can devise;
> With helmet heads and dragon scales adorn'd,
> The mighty myriads, now securely scorn'd,
> Would mock the majesty of man's high birth,
> Despise his bulwarks, and unpeople earth.[2]

In the winged or perfect state, hymenopterous insects generally occur on flowers, and they may be regarded as more abundant in southern than in northern regions. We shall not here dilate upon the generalities of the order, as it is our intention to notice all the more remarkable historical facts, in our sketch of the principal tribes and genera. We shall merely remark, that notwithstanding the numerous and always delightful observations of Réaumur, Degeer, Huber, Latreille, Walkenaer, and others, the hymenopterous order still presents a vast and fruitful field of discovery to the zealous cultivator of entomological science. Christus has combined in a special work[3] a great deal of excellent information; but his labours are imperfect in relation to the present condition of the subject. The *Systema Piezatorum* of Fabricius is merely a descriptive catalogue of species, assembled together without any precise notion of sexual distinctions, not seldom inaccurate in the exposition of generic characters, and extremely incomplete in relation to the European species. Jurine has carefully distinguished the sexes, and his groups are an improvement on those of his predecessors. Lepelletier de St-Fargeau,[4] Serville, Klug,[5] and, last though not least,

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directs itself towards the tip of the wing (fig. 3, *b*). This range is frequently divided into two, three, or four lesser cells, by means of intersecting nervures (fig. 4, *e*, and fig. 1, *e*). If two of these cells are much developed, and the second one, on the contrary, is so circumscribed that it cannot reach the margin of the radial nervure, we have then a peculiar character. The two developed cells, instead of being separated from each other by the entire interval of the second cell, are kept apart, for a space, only by a simple nervure, the length of which is proportional to the curtailment of the second cell; and in this way the latter has no other connection with the radial cell above it, than that it adheres to, or depends from it, as it were, by a kind of pedicle or stalk,—for which reason it is then named *petiolated* by Jurine (fig. 2, *b*). If it happens that the cubital nervure does not attain to the extreme margin of the wing, the spaces which it partly forms are regarded as *incomplete.*

It has been already stated that, besides the large nervures named cubitus and radius, Jurine has distinguished others, which also spring from the base of the wing, as at fig. 1, *g*. These produce others of a secondary kind, which mount towards the cubital cells, sometimes attaining to the first and second, sometimes to the second and third, and sometimes only to a single cell. These have received the name of recurrent nervures (fig. 1, *f*). By anastomosing among themselves, and with the cubitus, the brachial nervures and their branches form several cells, which Jurine has named the *humeral* (fig. 4, *h*, *h*, *h*, *h*, *h*). Of these Latreille distinguishes as *discoidal*, such as are situated in the centre of the wing (fig. 2, *i*, *i*). The recurrent nervures always concur in their formation. Among lepidopterous insects, the cell situated in the centre of the wing is prolonged uninterruptedly as far as the base.

Since we have entered into these details, we may here also mention briefly a few additional particulars, relating chiefly to the nomenclature of the outline of the wings. The *base* is that part which articulates with the thorax (fig. 1, *a*, *b*, *g*). The *point*, *summit*, or *anterior angle*, is that part which is most directly opposed to the base (fig. 1, *h*). The external, anterior, or upper margin of the wing extends from the base to the summit (fig. 1, *a*, *c*, *d*, *e*, *h*). The posterior, inner, or anal angle, is formed by the point of union of the posterior and inner margins (fig. 1, *i*). The posterior margin commences at the anterior angle or summit, and ends at the posterior or inner angle (fig. 1, *h*, *f*, *i*). The internal margin extends from the posterior angle to the base of the wing (fig. 1, *i*, *g*).

In addition to the works mentioned in a preceding note, see also the article AILES in the *Diction. Class. d'Hist. Nat.*; the article RADIALES in the *Encyclop. Méth.*; and M. Chabrier's elaborate *Essai sur le Vol des Insectes.*

[1] *Journal de Physique*, Sept. 1828.

[2] Cowper's *Retirement.*

[3] *Naturgeschichte, Klassification, und Nomenclatur, der Insecten vom Bienen, Vespen, und Ameisengeschlecht*, von J. L. Christ. Frankfort, 1791.

[4] In various articles and treatises in the *Encyclop. Méth.*

[5] *Monographia Siricum Germaniæ, atque Generum illis adnumeratorum, cum tab. æn. col.* Berlin, 1803; several memoirs regarding *Hymenoptera*, in the *Recueil* of the Society of Naturalists of Berlin; a critical review of the genera of Fabricius, derived from *Apis* of Linn. in Illiger's *Magazin für Insectenkunde*, &c.

Hymenoptera Terebrantia.

our own inestimable Kirby,[1] have published valuable though partial additions to our knowledge of the history and classification of the hymenopterous tribes.[2]

Latreille divides our present order into two primary sections.

TEREBRANTIA,[3]

In which the Females are provided with an Ovipositor.

FAMILY I.—SECURIFERA.[4]

Abdomen sessile, or united by the entire breadth of its base to the thorax, of which it appears a continuation, without distinct or separate power of movement. The females have an ovipositor (*tarière*), generally in the form of a saw, and which serves not merely for the deposition of the eggs, but also for the construction of a proper place for their reception. The larvæ have always six scaly feet, and frequently several others which are membranous. This family forms two tribes.

Tribe 1st, Tenthredinetæ, or Saw-flies.

Of these the mandibles are lengthened and compressed. The ligula is divided into three, as if digitated. The ovipositor is composed of two plates, toothed like a saw, pointed, united, and lodged in a groove of the posterior extremity. The maxillary palpi are always composed of six articulations, and the labial of four. The latter are always the shorter. Both pairs of wings are divided into numerous cells. This tribe corresponds to the great genus Tenthredo of Linnæus.

The abdomen of these insects is cylindrical, rounded posteriorly, composed of nine segments, and so united to the thorax as to appear almost like a uniform continuation of that part. The wings appear as if rumpled, and there are two little grain-like coloured bodies behind the scutellum. The form and composition of the antennæ vary. The mandibles are strong and toothed. The extremity of the maxillæ is almost membranous, or at least of a less coriaceous consistence than the base. The palpi are filiform, or nearly setaceous, and composed of six articulations. The ligula is straight, rounded, divided into three parts, of which the central is the narrowest; its sheath is usually short. The abdomen of the female is provided at its lower extremity with a double moveable ovipositor, scaly, serrated, pointed, and enclosed within two other concave plates, which serve it as a sheath. It is by the action of the teeth of this instrument that the insect perforates the stalks and other parts of plants, in which she lays her eggs. These she afterwards imbues with a peculiar frothy liquor, which seems to prevent the parts of the plant from reuniting, and even causes the formation of a concave chamber, or of ligneous parts resembling galls, in which the excluded larvæ dwell, either in a state of solitude, or in company, according to their kind. After undergoing its final metamorphosis, the perfect insect makes its escape by gnawing a circular overture. The larvæ of many species, however, live exposed upon the foliage of trees and plants. They bear a great resemblance to caterpillars in their general form and colouring, but they present either from eighteen to twenty-two feet, or only six; whereas in caterpillars properly so called, these parts range merely from ten to sixteen. They frequently continue in the larva state for several months, or throughout the winter, and remain but a short time in the nympha state, previous to the assumption of which they spin a cocoon. We shall briefly notice the principal genera into which these insects are now divided.[5]

In Cimbex of Olivier and Fab. (Plate CCXXXI. fig. 1) the antennæ are alike in both sexes, and terminate in a button-like expansion. The larvæ have twenty-four feet, and some of them when tormented will spout out a greenish liquid to the distance of a foot. In Hylotoma, Lat. (ibid. fig. 2), the antennæ exhibit only three distinct articulations, of which the last is in the form of an elongated prismatic or cylindrical club, more slender, ciliated, and sometimes forked in the males. A well-known species (figured as above), the *Tenthredo rosæ* of Linn. belongs to this genus. In the genus Tenthredo properly so called (ibid. fig. 3), the antennæ are composed of nine articulations, which are simple in both sexes. The larvæ have from eighteen to twenty-two feet. In the perfect insects the number of teeth of the mandibles varies from two to four. The amount of radial and cubital cells of the wings also varies in different species. Hence the formation of the genera *Allantus*, *Dolerus*, *Nematus*, &c. by Jurine, Leach, and other naturalists. The genus Cladius of Klug has also nine joints in the antennæ, but those parts are pectinated on one side in the males. In Athalia of Leach the body is short and thick, as in Hylotoma, but the antennæ, simple in both sexes, have from ten to fourteen articulations. The genus *Pterygophorus* of Klug are remarkable for their antennæ, composed at least of sixteen articulations, being pectinated or fan-shaped in the males, and serrated in the females. In Lophyrus of Lat. (Plate CCXXXI. fig. 4) the antennæ are doubly pectinated in the males, and resemble a triangular plume (fig. 5); they are shortly serrated in the females (fig. 6).[6] In all the preceding genera the labrum is quite apparent, and the four posterior tibiæ are either unfurnished on their inner side with spines, or exhibit only one. But in the following the labrum is concealed, or but slightly projecting, and the inner side of the four posterior tibiæ exhibits before its extremity two, and frequently three spines. Such are Megalodontes, Lat. in which the antennæ are serrated or pectinated, and Pamphilus of the same author, in which those organs are simple in both sexes.

The concluding Tenthredinetæ have the ovipositor prolonged beyond the groove, and projecting posteriorly. The antennæ are simple, and always composed of a great number of articulations. They constitute the genera Xyela, Dalm., Cephas, and Xiphydria, Lat. Of the last named the antennæ are inserted near the mouth, and become attenuated towards the termination (Plate CCXXXI. fig. 7).

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[1] In his *Monographia Apum Angliæ*, "ouvrage," says Latreille, "qui a immortalisé son auteur."

[2] Consult also the article Hymenopteres in the *Diction. Class. d'Hist. Nat.* t. viii. pp. 458–62.

[3] From *terebro*, to bore or pierce.

[4] From *securifer*, a hatchet-bearer, in allusion to the wood-cutting instrument with which these insects are armed,—which, however, happens to be a saw.

[5] For the details, see Lepelletier de St Fargeau's *Monographia Tenthredinetarum Synonymia Extricata*; Klug's *Entomologische Monographien*; Leach's *Zoological Miscellany*, vol. iii.; and *Règne Animal*, t. v. p. 271, &c.

[6] *Lophyrus pini*, the species figured on the plate referred to, has become much more common of late years in Scotland, since the plantation and growth of larch forests.

Hymenoptera Terebrantia.

TRIBE 2D, UROCERATA.[1]

The insects of this tribe are distinguished from those of the preceding by their mandibles, which are short and thick, by their ligula, which is entire, and by the ovipositor of the female, which is sometimes projecting and composed of three thread-like parts, sometimes spirally rolled within the abdomen, and of a capillary form. They compose the old genus SIREX of Linn.

The antennæ of these insects are filiform or setaceous, vibratory, and composed of from ten to twenty-five articulations. The head is rounded and nearly globular, the labrum very small, the maxillary palpi filiform, consisting of from three to five articulations, and the labial of three, of which the last is largest. The body is almost cylindrical. The anterior or posterior tarsi, and in several species the colour of the abdomen, differ according to the sexes. The females deposit their eggs in ancient trees, generally in those of the pine tribe. The ovipositor is lodged at the base of the abdomen, between two valves, which form a protecting groove.

In the genus ORYSSUS, Lat. (Plate CCXXXI. fig. 9), the antennæ are inserted near the mouth, the mandibles are without teeth, the maxillary palpi are long and five-articulate, the posterior extremity of the body is almost rounded and slightly prolonged, and the ovipositor is capillary and spirally rolled in the interior of the abdomen. There are only two species found in Europe, both of which are exceedingly active, and occur on trees in spring. We have figured *O. coronatus*, the sole British species. In SIREX properly so called (*Urocerus*, Geoff.), Plate CCXXXI. fig. 8, the antennæ, inserted near the front, consist of from thirteen to twenty-five articulations, the mandibles are toothed on their inner side, the maxillary palpi are very small, almost conical, of two articulations, and the extremity of the last segment of the abdomen is prolonged in the form of a tail. The ovipositor consists of three threads. These insects are of rather large size. They inhabit more particularly forests of pine and fir, in cold and mountainous countries, and during flight produce a buzzing noise, like that of an humble-bee. The larvæ have six feet, with the posterior extremity of the body terminating in a point. It lives in the interior of wood, where it spins a cocoon, and undergoes its metamorphosis. Our most noted species is the *S. gigas* of Linn. The male has a yellow abdomen, with a black extremity; the female is black, with a yellow spot behind each eye, and the second and three terminal rings of the abdomen also of the latter colour. Owing to the disparity of aspect of the sexes, they have been not unfrequently described by naturalists as distinct species.

FAMILY II.—PUPIVORA.[2]

The various groups which compose this family are distinguished by the abdomen being attached to the thorax by a simple portion of its transverse diameter, or even in many instances merely by a slender thread or pedicle, so that its mode of insertion is distinct and obvious, and admits of a separate movement. The larvæ are apodal, and for the most part parasitical and carnivorous. Latreille divides them into six tribes, as follows.

TRIBE 1ST, EVANIALES.

In these the wings are raised, and the upper at least are areolated. The antennæ are filiform or setaceous, and composed of from thirteen to fourteen articulations. The mandibles are dentated on the inner side. The maxillary palpi consist of six, and the labial of four articulations. The abdomen is implanted on the thorax,—in some, just beneath the scutellum. The ovipositor is usually projecting, and composed of three setæ.

The following are the principal genera: EVANIA, Fab. (*Sphex*, Linn.) Plate CCXXXI. figs. 10 and 13; PELECINUS, Lat., ibid. fig. 12; FÆNUS, Fab. (*Ichneumon*, Linn.) ibid. fig. 14; AULACUS, Jur. and PAXYLLOMA, Brébisson.

TRIBE 2D, ICHNEUMONIDES.

In these the wings are also veined, and the superior always exhibit on their disc closed or completed cells. The abdomen takes its rise between the two posterior legs. The antennæ are generally filiform or setaceous (very rarely clubbed), and composed of a great number of articulations. In the majority the mandibles have no tooth on the inner side, and terminate in a bifid point. The maxillary palpi, always apparent or projecting, have usually not more than five articulations. The ovipositor consists of three threads or setæ.

Such is a brief exposition of the technical characters of a tribe of insects which embraces almost the whole of the great genus ICHNEUMON of Linnæus, and of which the natural economy and habits are so remarkable that we shall here take leave to extend our observations on their history. Perhaps we could not better illustrate the complex nature of the modern science of Entomology than by stating, that what we must here pass over in the space of a few columns, and which, even in the publications of comparatively recent writers, does not form a very important or greatly enlarged feature, occupies, in a work to which we have lately devoted our attention, upwards of 2800 pages.[3]

The general term Ichneumonides comprehends an extensive series of insects, important on account of the purposes to which they are subservient in the economy of nature, and deriving considerable interest from the peculiar manner in which these purposes are effected. They differ from most of the other members of the class to which they belong, in their mode of providing for their young,—presenting this peculiarity, that they deposit their eggs in the living bodies of other insects. In a tribe of such extent, considerable variety of external appearance necessarily prevails; but a genuine Ichneumon may in general be known by its elongated form, attenuated, and in most cases petiolated abdomen, terminated frequently in a long fissile seta; and by its filiform, porrected, often recurved and annulated antennæ, to which a constant vibratory motion is imparted. The European species vary in size from a fraction of a line to fifteen lines; those of tropical countries, however, greatly exceed these dimensions, a few of them ranking even among the largest insects. Upwards of 1300 species have been described as natives of Europe, of which number a great many hundreds exist in Britain.[4] The frequency of their occurrence, and singular habits of life, which often force them unexpectedly on the notice of naturalists while engaged in the study of insect transformations, have secured some degree of attention for this tribe, even from the earliest periods. The word Ichneumon occurs in the natural history of Aristotle, by whom it is applied to a species of Sphex. Ray appears to be the first who used it to designate the tribe of insects to which it has ever since been restricted. Little, however, was known regarding the structure or habits of these creatures till the time of Frisch, who subjected them to an anatomical examination, and described the parts of the mouth, and formation of the wings, with great accuracy and minuteness. He was the first who employed the form and relative position of the cells of the latter to assist in distinguishing genera. Much valuable information resulted from the observations and experiments of Réaumur, whose work may be referred to for many interesting details regarding the manners and habits of the Ichneumonides.[1] Degeer also contributed materially to elucidate their history, and proposed a new arrangement of the family, characterized by his usual accuracy of discrimination.

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[1] From ουρα, *tail*, and κερας, *horn*.

[2] From *pupa*, and *voro*, to devour, in allusion to their destruction of other insects by depositing eggs in their bodies, which usually destroy the pupæ.

[3] We allude to the complete and careful *Ichneumonologia Europæa* of Professor Gravenhorst of Breslau, in three very thick volumes 8vo, 1829.

[4] In the *Systema Naturæ* (12th edition), Linnæus describes only seventy-seven species of Ichneumon.

In the numerous works on Entomology which appeared during the latter half of the eighteenth century, our knowledge of these insects kept pace with the increased zeal manifested towards the study of natural history during that important period. Linnæus, Scopoli, Fabricius, Schrank, Panzer, and others of inferior name, applied themselves successfully to investigate their history—reducing the information derived from their predecessors to a more systematic form, and greatly increasing the amount of known species. In 1807 Jurine published his new method for the classification of Hymenoptera, already mentioned. The application of his principles to the Ichneumonides afforded less satisfactory results than in most of the other tribes. Like all systems founded on a partial view of organic structure, it led, in many instances, to the violation of natural order, by separating cognate species, and associating others having no positive affinity. But though Jurine failed to establish an efficient mode of arrangement, he rendered important service to subsequent inquirers, by describing minutely, and furnishing with a suitable terminology, the variously modified forms of the organs of flight, which are found to afford characters of considerable value for the discrimination of genera. Latreille at different times published arrangements of this tribe, and by the number of his sectional divisions, generally founded on obvious characters, greatly facilitated the identifying of species.[2] But the amount of these had increased to such an extent, and they were found to approximate so closely to each other in external characters, that a comprehensive division, and a more detailed description of specific difference, became indispensable. This desideratum has recently been supplied by the publication of an extensive and elaborate work on the Ichneumonides by Professor Gravenhorst; an individual eminently qualified to unravel the complexities of this difficult tribe. An extensive intercourse with men of science enabled him to amass a large collection of these insects from all parts of Europe; while habits of minute observation and patient research, combined with just views of systematic arrangement, and an accurate perception of the affinities of consecutive groups, qualified him to employ to the best advantage the ample materials thus obtained. The result of his labours appeared in 1829, as specified in a note on our preceding page. The arrangement adopted is fundamentally the same as that previously published by himself and Nees ab Esenbeck.[3]

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Terebrantia.

The body of the Ichneumons is more or less elongated, and in most instances naked and shining, seldom rough or impressed with punctures. It is occasionally covered, particularly on the head and thorax, with a pubescence composed of slender erect hairs, or it is somewhat sericeous and opaque, with a soft decumbent pubescence. The prevailing colours are rufous, black, and yellow, variously intermingled with lines and patches of white. In the great majority of species, there are one or two spots of the latter colour on the thorax, at the insertion of the wings. The scutellum is most frequently white. The feet are very often of a reddish colour, at times red and black; but they are never entirely black, the anterior femora being always pale on the under side. The head is prominent, generally orbiculate or subovate anteriorly, in many instances a little narrowed towards the neck, and nearly of the same breadth as the thorax. The forehead is sometimes armed with one or two short erect horns, placed between the antennæ and stemmata. The latter are three in number, and disposed in a triangular form. The antennæ in the greater number of species are shorter than the body; in a few they are of the same length, very rarely longer, porrected, generally curved or involuted after death, especially in the females, filiform or setaceous, sometimes slightly compressed at the middle, as in some species of *Phygadeuon*, distinctly compressed in the *Barycerotes*, much compressed and dilated in the *Eucerotes*, and clavate in the *Hellwigiæ*. They consist of from eighteen to sixty articulations, of which the first or radicle is small, globose, and sunk in the head; the second or scape sub-cylindrical or sub-clavate, rarely ovate, very rarely sub-globose, always thicker than the rest (except in the antennæ of the *Barycerotes* and the *Eucerotes*), and longer than the two following; the third and fourth very short, rather stout, and often so closely united that they may be regarded as one joint; the fourth always shorter than the third, which is at times very inconspicuous; the fifth long, cylindrical; the remainder gradually decreasing in length, so that the apical joints often appear transverse. Such is the general appearance of the antennæ; but they are liable to numerous modifications. The mandibles are corneous, more or less arcuate, generally broadest at the base, and narrowed towards the apex; in a few instances they are straight, and in others linear, or even dilated at the extremity, where they are furnished with two teeth, except in a very few species, which have the apex entire or tridentate. The maxillæ consist of two parts, of which the basal portion, or stipes as it has been called, is usually of a corneous consistence and somewhat lanceolate form; the other portion (mala) is of a membranaceous substance, and bifid or bipartite. The palpi are four in number, elongate, filiform, and unequal; the maxillary are rather long, and consist of five joints, very rarely of four. They have been described by Fabricius and Panzer as having six joints. The third joint is generally the longest; the first, second, and fourth, very short; sometimes, however, one or other of these, or the fifth, is longest, and in a very few cases the third is shortest; in some species all the articulations are of equal length. The labial palpi are rather short, and consist of five joints, very rarely of three.

The Ichneumonides, like the rest of the Hymenoptera, are provided with four wings, composed of thin membrane, and of corneous ribs. These ribs are generally denominated nerves or nervures; and the various spaces into which the wing is divided by their intersection are called

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[1] *Mémoires*, tome ii. iv. et vi.

[2] *Histoire Naturelle, générale et particulière, des Crustacés et des Insectes*, tom. iii. et xiii.; see also *Règne Animal*, t. v. p. 281.

[3] The arrangement alluded to appeared in 1818, in the 9th volume of *Novorum Actorum Academiæ Naturæ Curiosorum.*

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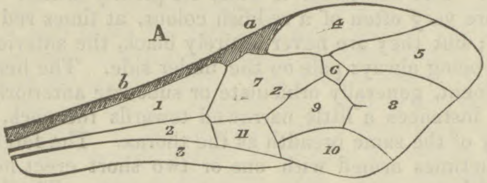
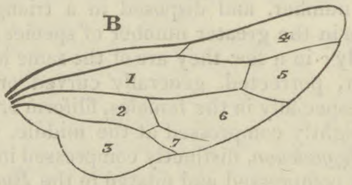
cells or areolets. The base of the wing (*radix*), or that portion of it which is inserted into the thorax, is of a substance intermediate between corneous and membranaceous, and is always more or less coloured. It is partially covered with a hard convex scale (*squamula*), which, however, may more properly be regarded as an appendage of the thorax. The anterior wings (fig. A) are longer than the posterior, narrow throughout a considerable portion of their length, and gradually dilated towards the extremity. The *stigma* (*a*) is distinctly marked, and varies much in size. The thick rib of the anterior margin, extending between the stigma and the dorsal angle of the wing, is called the *radius* (*b*). By the anastomosing of the nerves, ten or eleven cells are formed, of which the three at the base of the wing are named humeral (*humerales*), 1, 2, 3; one radial (*radialis*), 4; two or three cubital (*cubitales*), 5, 6, 7; two lying under these discoidal (*discoidales*), 8, 9; and two towards the margin posterior (*posticæ*), 10, 11. When the cells are viewed in relation to the breadth of the wing, the three situate at the apex or posterior margin are said to be external (5, 8, 10); those next the humeral cells internal (7, 11); and those between the external and internal cells intermediate (6, 9). Of the humeral cells, that which lies next the radius is named the external (1), that next the margin the internal (3), and that which lies between these two the intermediate (2). The intermediate cubital cell (6) is generally denominated the areolet, and is important on account of the distinctive characters it affords. The interior cubital cell (7) is very large, in consequence of the nerve which ought to divide it into two parts, at least which does so in the other Hymenoptera, having become obsolete. In many species, however, a portion of this nerve is visible (*z*); and in some instances it extends nearly to the centre of the cell; but it is usually very short, or a projecting angle alone indicates the point whence it ought to issue; and in the less typical species all traces of it are obliterated. The areolet likewise is occasionally awanting; different individuals of the same species have it or have it not; and examples occur in which it is distinctly formed in one wing and awanting in the other. In general, however, it is present, and may readily be distinguished from the other cells by its inferior size and angular form. It is either five-angled or quadrangular, triangular or orbiculate. But all these forms are liable to numerous modifications, and one passes into another. The posterior wings (B) are shorter and narrower than the anterior, and nearly of equal breadth throughout. By the anastomosing of the nerves, seven cells are formed, of which the three at the base of the wing are named internal (1, 2, 3), and four at the posterior margin external (4, 5, 6, 7). In the sub-genus *Pezomachus* the wings are generally absent, and when present are extremely imperfect, and usually unfit for the purposes of flight, although their structure, as far as it can be traced, exactly corresponds to that of the more perfect species. The abdomen, which is very variable in form, is composed of seven or eight segments, the eighth being more or less concealed, and often entirely obsolete. This imperfect development of some of the segments has led authors to give various accounts of their number. In addition to the seven usually enumerated, Audouin is of opinion that there is another of very small size, which unites the abdomen to the thorax. According to Blainville, there are never fewer than ten segments, of which the two at the apex are always concealed. The first or basal segment bears on each side of it a small tubercle, more or less distinct, which forms the outlet to a spiracle. When the tubercles are placed very near the base, and the anterior part of the basal segment is not much narrower than the following segments, and these nearly correspond to the breadth of the thorax, the abdomen is said to be sessile; the posterior part of the first segment being so short that it can with difficulty be distinguished, and the anterior part consequently appearing to adhere immediately to the thorax. If this segment, or the posterior part of it, be gradually contracted towards the base, the abdomen is said to be sub-sessile or sub-petiolate. When the posterior part is narrow and elongated, linear or filiform, that part is called the petiole or footstalk, and the abdomen is said to be petiolate.





The sexes of these insects can with difficulty be distinguished,—few species affording any permanent external marks of sexual difference. The males in some instances differ from the females in having a more slender abdomen, in others the antennæ are thicker, and in some species they are more slender than in the females. Many of the latter are distinguished by having a white ring round the antennæ,[1] which after death become curved or spirally convoluted. The males may frequently be known by having the colours with which they are adorned clearer and more distinctly defined than in the opposite sex. But the most certain, and often the most obvious mark of sexual distinction, is the ovipositor with which the females are provided. This remarkable appendage varies in its form, in fine accordance with the varied economy of different species. Some Ichneumons deposit their eggs on the bodies of caterpillars; an operation which they accomplish by merely piercing the skin. Others, in order to lodge their eggs in a proper receptacle, are obliged to perforate the nests of insects, and to penetrate to the bottom of crevices too narrow to admit of the whole body. The former are furnished with a short, retractile ovipositor, seldom exserted, and lodged in a groove on the under side of the abdomen. But the ovipositor of the latter is often of considerable length, exceeding in some instances that of the whole body. It is composed of three parts; that in the centre is a slender flexile seta, of a corneous substance, very smooth and shining, generally straight and rounded, rarely arcuate and compressed, and most commonly of a rufous or castaneous colour. It is provided with a longitudinal central canal, through which the eggs are propelled. The apex is often compressed and dilated, and impressed with transverse inequalities; it is frequently compressed throughout its whole length, and occasion-

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[1] In regard, however, to this distinctive character between the sexes, Gravenhorst observes in his preface (page 10)—" nonnullarum mares quoque hoc ornamento gaudent."

ally bent upwards at the extremity. On each side of this central seta is placed another, adapted, by the concavity of the inner surface, to enclose it as in a sheath. These lateral appendages are generally punctate and pubescent externally, and somewhat incrassate towards the apex. They issue from the terminal segment of the abdomen; but the central tube or oviduct originates in the interior, and must necessarily be connected with the viscera, to whose contents it forms the outlet.

When a female Ichneumon, furnished with an apparatus of the kind just described, has discovered the retreat of a larva or pupa, in which she wishes to deposit her eggs, she stations herself immediately over the spot, and raising her abdomen to a vertical position, bends the ovipositor under her belly, and thrusts it into the aperture. This operation is much facilitated by the great flexibility of the instrument, and the ease with which it can be accommodated to any circumstances in which it requires to be employed. It penetrates to a considerable depth into the body of the larva, lest the eggs, by being placed near the surface, should be thrown off when the skin is changed. Upon their exclusion from the egg, the parasitical young make their way still farther into the interior of the larva, consuming the fat that surrounds the muscles and viscera, but carefully abstaining from doing injury to the vital organs. In this state they are gregarious, and were found by Réaumur (who has given a figure of a caterpillar so infested) to be arranged in regular rows in the interior of the caterpillar. When they have arrived at maturity, they undergo their destined change either in the body of the larva which served them as a matrix, or, gnawing a passage through its skin, they construct externally their silk cocoons, and are then converted into pupæ, from which, after a longer or shorter period, they emerge in their declared or perfect form.

A still more remarkable method of rearing its offspring is adopted by the *Ophion luteus*, and probably by all the other species belonging to that genus.[1] The eggs of this insect are deposited on the caterpillar of the Puss Moth (*Cerura vinula*), to which they firmly adhere by means of an elongated pedicle or foot-stalk. When the larvæ are evolved, they do not enter the body of the caterpillar, but remain attached to the columnar appendage, through which they extract, by suction, the juices necessary for their sustenance. The caterpillar dies before it assumes the pupa state, but this event in no case proves fatal to the larvæ, as it either does not occur till they require no further nourishment, or they avail themselves of that principle of accommodation to existing circumstances, which insects possess in such a remarkable degree, and undergo their destined changes as soon as their supply of food begins to be withdrawn.

Ichneumons are generally active and rapid in their motions; many of them, particularly those belonging to the genera *Ichneumon* proper, and *Cryptus*, continually vibrate their antennæ, a circumstance which induced the older writers to call them *Muscæ vibratoriæ;* others, such as the *Ophiones*, are of slower habits, and have not been observed to exhibit this peculiarity in the movements of their antennæ. The larger species fly with considerable celerity, and cannot very readily be approached, unless when engaged in depositing their eggs; an operation with which they are so entirely engrossed, that all regard for their own safety appears to abandon them. They occur in flowers, on the trunks of trees, and on plants; also on walls and in houses; but their favourite places of resort are the flowers of umbelliferous plants. The species furnished with a long ovipositor usually frequent walls and the trunks of trees, for it is in these situations that they find the larvæ on which a singular instinct leads them to deposit their eggs.

Our knowledge is obscure regarding the food of these insects in the perfect state; but it appears to be derived from the vegetable rather than the animal kingdom. We kept one alive, however, during the greater part of a winter on calf-foot jelly. They have often been observed to examine carefully with their mouths the pollen of plants; and it is probable that the pollen, or rather the honey, of flowers, affords them nourishment. Indeed it is expressly affirmed by Fabricius, that it is this material which forms their food. They do not seem to attack or devour other insects, or larvæ, or spiders, but associate with them without offering the least annoyance. It is likely, therefore, that those authors who assert that they are of predatory habits, mistook for Ichneumons certain species of an allied group (*Spheges*), to which they bear resemblance. Whenever they attack a larvæ, it is not for the purpose of employing it as food, but to convert it into a matrix for the reception of their young. But, though they do not devour spiders, as has been asserted, that insidious tribe of creatures is by no means exempted from their destructive visits,—for they oviposit either on the spiders' eggs, or on the dense silky web in which these are frequently enveloped; and the larvæ when excluded consume the substance of the eggs, and are then changed into nymphs and perfect insects within that silken chamber, so carefully constructed for a far different purpose.

The larvæ of the Ichneumonides are without feet. The tissue of their cocoons is of fine silk, usually of a beautiful yellow, or pure white, according to the species. Some, however, are banded with brown and yellow. We have already stated that their positions are various. A remarkable instance is occasionally met with of a *suspended* cocoon. It hangs to the leaves or twigs of the oak-tree, fastened at one extremity by a silken cord. This cocoon is farther remarkable for the manner in which it executes little springs, several inches in height. These are no doubt occasioned by the enclosed larva, which probably has space enough within to admit of its body being bent and retorted, after the fashion of the little worms which we sometimes see vaulting within the hollow walls of an old cheese.

Several Ichneumons are apterous. These Linnæus placed with the Mutillæ. Degeer describes one which proceeded from a ligneous gall which he found upon the stalk of a species of Potentilla. It first attracted his notice by two inflated conical pieces, pointed at the end, attached to the upper and posterior portion of the thorax, and directed backwards. They were moveable at the base, and the insect worked them about in all directions while itself in motion. It was extremely small, and leapt with great activity. As its hinder thighs were not enlarged, Degeer inferred that its springs were produced by curving its abdomen, and then pressing that part forcibly against the plane of its position.

In regard to the situations most favourable for collecting Ichneumonides, we may observe, that wherever other insects, especially in the larva state, abound, there also we may expect to find multitudes of these parasitical depredators. Having so greatly extended our general observations on this interesting tribe, our limits will less easily admit of our entering into descriptive details of genera and species. For these the reader must consult the works to which we have alluded. We shall however

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[1] Degeer, ii. p. 850, pl. xxix. fig. 15.

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enumerate the genera adopted by Latreille. They are as follows: Stephanus, Jur. (Plate CCXXXI. fig. 15 and 16); Xorides, Lat.; Pimpla (ibid. fig. 19); Cryptus, Ophion, and Banchus, Fab., Helw.; Joppa, Fab. (ibid. fig. 21); Ichneumon proper (ibid. fig. 17); Alomya, Fab.; Peltastes, Illiger (ibid. fig. 18); Acænitus and Agathis, Lat.; Bracon, Jur.; Microgaster, Lat.; Helcon, Nees d'Es.; Sigalphus, Lat.; Chelonus, Jur.; Alysia, Lat.[1]

We shall now exhibit a few examples of Gravenhorst's systematic exposition of the Ichneumonides, and these we shall select from British species.

Genus Ichneumon, Grav. Abdomen petiolate, convex; head transverse; scutellum flat or convex; areolet in most instances pentagonal; (ovipositor concealed or sub-exserted).

This genus includes a great many sub-genera, of which we shall choose the first, or that which bears the same name as its principal, viz.

Sub-genus Ichneumon. Abdomen oblong or sub-ovate; the first segment globose, rough, the petiole long, linear, arcuate; areolet pentagonal; antennæ and feet of moderate or medium size; (ovipositor concealed or sub-exserted).

Section 7th of Gravenhorst.

Scutellum pale; the abdomen either with pale markings, or some of the segments entirely yellow, the apical segment black.

I. *luctatorius*, Fab. Linn. Lat. Grav. Length of the male from five to nine, of the female from five to seven and a half lines. The head of the male, with the mouth and face, yellow; of the female, either entirely black, or, with the interior orbits of the eyes, a lateral spot on the clypeus, the palpi and mandibles, yellow, the apex of the latter fuscous. Antennæ of the male porrect, setaceous, half the length of the body, or a little longer, the first joint yellow beneath; those of the female half the length of the body, curved at the tip, from the ninth to the thirteenth, or from the twelfth to the fourteenth joints, white above, the basal joint sometimes ferruginous beneath. Thorax gibbous; with a yellow line or spot before the wings, and another beneath them, one of which is occasionally awanting; the anterior line, in the female, ascending as far as the neck, of which the upper margin, in the male, is at times yellow; the male has sometimes a yellow spot beneath the scutellum. Scutellum yellow. Wings of moderate size, or rather ample, silaceo-hyaline; the stigma fulvous or ferruginous, rarely fuscescent, the radius fuscous or ferruginous; the radix yellow or ferruginous, rarely fuscous; the squamula either yellow or fuscous, with a whitish or rufescent spot; the areolet pentagonal. The feet of moderate size; the anterior femora on the under side, and for the most part at the apex also, yellow, black towards the base, and sometimes entirely black: the intermediate femora, with the apex, sometimes as far as the middle, and in a few cases the whole under surface, yellow; tibiæ yellow, the posterior black or fuscous at the apex; tarsi yellow, or flavo-ferruginous, the posterior with the tips of the joints sometimes blackish. Abdomen of the male elongated, longer sometimes by one half than the head and thorax, of the same breadth or a little narrower than the thorax, from the second to the third segments nearly of equal breadth, the following gradually narrowed towards the extremity; that of the female oblongo-ovate, a little longer than the head and thorax, and of the same breadth, the apex acute; the second and third segments yellow, in some females mixed with ferruginous and the margins fuscescent; the second segment of the males occasionally with a lateral abbreviated fuscous line, the third with a transverse line or two fuscous spots at the base; the fourth generally with a fulvous or rufous spot in the angles at the base, and more rarely the outer margin, or the base, or a lateral mark, rufescent or yellowish; the fifth very rarely with the outer margin yellowish.

The males of this species occur in considerable profusion in Britain, and throughout the greater part of Europe; the females are very rare.[2] They frequent sides of fields, and open places in woods, and are often to be found on umbelliferous plants during the autumnal months. They are liable to great variation both in size and colouring. Roxburghshire, and near Edinburgh, in considerable plenty.

Genus Tryphon, Grav. Abdomen convex, petiolate, or sub-sessile; head transverse; scutellum flat or convex; areolet triangular, or irregular, or absent; (ovipositor concealed, or sub-exserted).

Sub-genus Tryphon. Abdomen oblong, sub-sessile, or sub-petiolate; antennæ slender or middle-sized; feet of moderate length.

Section 4th of Gravenhorst.

Scutellum black, abdomen either entirely rufous, or rufous and black, or yellow and black.

T. *elongator*, Grav. Fab. Length from two and a half to five lines. The mouth generally rufescent, the apex of the mandibles black, or entirely black. The forehead with an erect horn, variable in length, but never exceeding that of the basal joint of the antennæ. Antennæ setaceous, shorter than the body; the first joint black, very rarely ferruginous beneath; the following generally fulvous or ferruginous, fuscous above, sometimes entirely fulvous or ferruginous. Thorax gibbous. Wings most commonly yellow-hyaline; the stigma and radius ferruginous, or pitchy straw-coloured, the radix straw-coloured, the squamula either black or pale ferruginous; areolet irregular or sub-triangular, sub-petiolate or sessile. Feet rather stout, the coxæ and trochanters black; the anterior femora yellow or testaceous, black externally towards the base; the intermediate femora black, with the apex yellow or testaceous, sometimes almost entirely testaceous on the under side; the posterior femora entirely black; the tibiæ yellow, rarely testaceous, the hinder with the apex and base black; the tarsi rufous or rufo-ferruginous, claws fuscous. Abdomen sub-petiolate, generally longer than the head and thorax, and nearly of the same breadth, sub-clavate, or sub-ovate, or fusiform; first segment canaliculate, gradually dilated towards the apex, about one half longer than broad, generally black, with the margin ru-

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[1] For their characters, see *Règne Animal*, t. v. pp. 285–90.

[2] It is probable that the predominance in number of one sex over the other, so often alluded to by authors as an anomalous fact in the history of Ichneumons, is more apparent than real, and arises, in some instances, from the distinctive marks of sex being so slight as to elude observation, while in others the sexes are so dissimilar that each of them is received as a different species. The determination of the sexes is impeded by the difficulty of observing their intercourse. "Nunquam mihi successit," says Gravenhorst, "par copula junctum aut copulam parans invenire, licet forsan centum millia individua viva Ichneumonidum, in statu eorum libero naturali, viderim, et per triginta annos omnem operam dederim ut copulam viderem." (Vol. i. page 98.)

Hymenoptera Terebrantia.

fous or fulvous, sometimes almost entirely rufous or fulvous, with the base black; the second, third, and fourth segments, sometimes also the base of the fifth, yellow or fulvous. Ovipositor very short, black, generally concealed.

This species abounds in most parts of Europe. It is plentiful in England, and is not unfrequent in Roxburghshire and other southern counties of Scotland. It likewise occurs near Edinburgh.

Genus Alomya, Grav. Abdomen petiolate, convex; head globose; areolet triangular.

A. *ovator*, Grav.; *Ich. ovator*, Fab. Lat.; *Ich. elongator*, Gmel. Oliv. Length from five and a half to seven and a half lines. Head sub-globose, somewhat quadrate when viewed from above, with the angles obtuse, sub-transverse; the face sometimes with a slightly elevated tubercle. Antennæ of the male setaceous, shorter than the body, or nearly of the same length, porrect, entirely black; those of the female moniliform, not half the length of the body, incurved at the apex, from the third to the thirteenth or fourteenth joints, ferruginous or testaceous, gradually becoming paler. Thorax very slightly gibbous. Scutellum triangular, flat. Wings of moderate size, hyaline or smoky-hyaline, the stigma ferruginous or fulvous, the radius piceous, the radix piceous or fuscous or ferruginous, the squamula black or fuscous; areolet pentagonal. The feet of the male with the coxæ and trochanters black; the femora of the fore legs ferruginous or fulvous, generally with the apex sub-testaceous and the base black; those of the middle legs generally black, with the apex ferruginous; those of the hind legs entirely black; the tibiæ yellow or testaceous, the hinder occasionally with the apex fuscous; the tarsi testaceo-ferruginous. The legs of the female are shorter and thicker than in the male, the coxæ, trochanters, and femora black, the latter, in the fore legs, for the most part almost entirely, or the apex only, rufous or ferruginous; the tibiæ either entirely ferrugino-testaceous, or testaceous with the apex ferruginous; tarsi fusco-ferruginous. Abdomen petiolate, convex, elongate; that of the male rather more than one half longer than the thorax, and nearly of the same breadth, the segments from the second to the sixth equally broad; the petiole linear and slender; the colour black and rufous, variously intermingled. Ovipositor concealed.

This species is of frequent occurrence both on the continent of Europe and in Britain. Gravenhorst is of opinion that *Alomya victor*, Curtis, *Ent. Brit.* 120, is a variety of this species.

Genus Cryptus, Grav. Abdomen petiolate, convex; head transverse; scutellum flat or convex; (ovipositor exserted.)

Sub-genus Pezomachus, from πεζομάχος, *a fighter on foot*, because the species, from the imperfect development of the organs of flight, are unable to attack larvæ on the wing. Body small; abdomen petiolate; wings awanting or very small; ovipositor exserted, short, or of ordinary length.

P. *Hopei*, Grav. *Supplementa Partis* ii. vol. i. p. 715. Length from two and a fourth to two and a half lines. Head black, palpi rufous. Antennæ slender, curved, rather more than half the length of the body; from the first to the fifth joint rufous, the sixth or the sixth and seventh fuscous, from the eighth to the eleventh white, rufous beneath, the remainder rufous, fuscous above. Thorax and scutellum rufous; metathorax with two very short obtuse spines. Wings shorter than the thorax. Feet somewhat slender, rufous; the apex of the hinder femora, and sometimes of the tibiæ, black, the base of the latter whitish. Abdomen scarcely longer than the head and thorax, and a little broader, oblong-ovate; the three basal segments rufous; the fourth, with the sides and sometimes the base, also rufous; the fifth and sixth black; the seventh white. Ovipositor rather more than half the length of the abdomen, the sheath black, the tube rufous.

This insect, hitherto found in Britain only, occurs not unfrequently in oak coppices in Roxburghshire, near Minto, Cavers, &c. It is named by Gravenhorst after a distinguished English collector, our honoured correspondent, the Rev. F. W. Hope, by whose effective practical researches the *Ichneumonologia* has been enriched by many new species.

Genus Pimpla, Grav. Abdomen convex, sessile; scutellum triangular or sub-orbicular; (ovipositor exserted).

Sub-genus Lissonota, from λισσὸς, *smooth*, and νῶτος, *the back*, in allusion to the smooth upper surface of the abdomen. The abdomen in most smooth, shining; the apical segments of the female entire on the under side; areolet either awanting or triangular; (ovipositor long).

Section 1st of Gravenhorst.

Scutellum and abdomen black; the latter sometimes with the apical margin of the segments castaneous.

L. *setosa*, Grav.; *Ich. setosus*, Oliv.; *Ich. immaeulatus*, Gmel.? Length from seven to nine lines. Labrum sometimes obscurely ferruginous. Antennæ subfiliform, somewhat incurved and tapering towards the apex, half the length of the body, at times nearly of the same length. Thorax slightly gibbous. Wings of moderate size, smoky-hyaline, the stigma and radius nigro-fuscous, the radix piceo-fuscous or piceo-ferruginous, the squamula black or fusco-ferruginous; areolet sessile or sub-petiolate, triangular. Feet elongate, fulvous, the coxæ black, the posterior tarsi for the most part black or fuscous. Abdomen a little longer and narrower than the head and thorax, or of the same breadth, punctate; that of the male sub-cylindric, somewhat narrowed towards the apex; that of the female oblong or sub-cylindric; the margins of the segments elevated, shining; the first segment sub-canaliculate; the third sometimes fuscous. Ovipositor the length of the body; the tube black or fusco-castaneous, rarely fulvous.

This insect is pretty widely distributed over the north of Europe, and is found occasionally in England.

Sub-genus Pimpla. The segments for the most part transversely impressed, the intermediate ones broader than long, those at the apex having, in the females, a longitudinal groove or fissure on the under side; the areolet triangular; (ovipositor of moderate size, rarely long).

Section 6th of Gravenhorst.

Scutellum, thorax, and abdomen black; the latter sometimes with rufous bands; posterior coxæ black.

P. *examinator*, Grav.; *Cryptus examinator*, Fab.; *Ich. rufescens*, Gmel. Length of the male from one and two thirds to four and a half, of the female from two and a half to six lines. Palpi of the male whitish or yellowish, rarely piceous. Antennæ of the male either entirely black, or ferruginous on the under side towards the tip, with the first and second joints, or the first only, whitish. Thorax of the female, rarely that of the male also, with a whitish or straw-coloured line or spot, sometimes obsolete, before the wings. Wings smoky-hyaline; the stigma and radius black or fuscous, rarely piceous; the radix straw-coloured, in the females for the most part ferruginous or fuscous; the squamula of the male straw-coloured or fuscous, of the female ferruginous or fuscous, generally with a whitish spot, seldom entirely whitish; the areolet irregular, sessile or sub-sessile. Anterior feet rufous or fulvous, the coxæ and trochanters black, in the male sometimes yellow beneath, the tibiæ generally with a pale ring near the base; the posterior legs, with the coxæ, black, having very rarely a rufous mark, or the outer side entirely rufous; trochanters black, the apex in the male generally rufous; femora rufous or rufo-fulvous, the knees sometimes black, the whole outer side in some females black; tibiæ blackish, with a whitish ring near the base, in the male sometimes rufous near the apex; tarsi of the male black, of the female fuscous or fusco-ferruginous. Abdomen of the male longer, and rather narrower than the head and thorax, sub-cylindrical; that of the female a little longer than the head and thorax, sometimes twice the length of the thorax, and of the same breadth, sub-cylindrical or oblongo-ovate; the first segment scrobiculate at the base, the rest with their apical margins somewhat elevated, shining, and generally obsoletely castaneous, in the male sometimes ferruginous. Ovipositor half the length of the abdomen, or a little shorter.

This species usually deposits its eggs on the larva of some kind of moth, and specimens have been obtained from the pupa of *Tinea padella*, and *Bombyx fuliginosa.* It is not a scarce insect on the continent of Europe, and it occurs both in England and Scotland. Near Cavers, Roxburghshire, and in the vicinity of Edinburgh.

Sub-genus Ephialtes. Abdomen long, in most instances tuberculated; the anterior segments, and generally the intermediate ones also, longer than broad, those at the apex with a longitudinal groove on the under side in the females: areolet triangular: (ovipositor long).

E. *manifestator*, Grav.; *Ich. manifestator*, Linn. Length of the male from six to eleven, of the female from nine to fifteen lines. Palpi fuscous or ferruginous, the labrum sometimes obscurely ferruginous. Antennæ filiform, half the length of the body, or a little longer, porrected, often slightly curved at the tip. Thorax occasionally with a minute testaceous or ferruginous spot at the base of the wings. Wings of moderate size, more or less smoky-hyaline, the stigma more or less obscure; radius fuscous, radix and squamula ferruginous or straw-coloured, areolet somewhat regularly triangular, sessile or sub-petiolate. Feet somewhat slender and elongated, fulvous or rufous; the posterior tarsi and tibiæ, and sometimes the knees, fuscous, the tibiæ for the most part ferruginous towards the base, especially on the inner side. Abdomen more than one half, or three times longer than the head and thorax, of the same breadth as the thorax, or a little narrower, cylindrical, black, very rarely fuscous; the first segment canaliculate, the rest more shining, with an obsolete lateral tubercle and elevated margins, the length of the segments from the first to the fifth exceeding their breadth often by one half. Ovipositor longer than the body, rarely of the same length, the sheath somewhat pilose; the tube fuscous or rufo-castaneous, rarely black or straw-coloured, the apex sub-compressed, lanceolate, faintly impressed with transverse lines.

This insect, which is the largest of the European Ichneumonides, occurs not unfrequently in many parts of Europe. It is found in England; and in Scotland it has been observed in Roxburghshire, and near Edinburgh. "On the first of October," says Gravenhorst, "I observed many females of this species on the decaying trunk of a willow, about to deposit their eggs. They traversed with much assiduity the barkless trunk, which was perforated with numerous holes, inhabited no doubt by the larvæ of other insects; and so free were they from apprehension, that when I touched them with my finger they did not fly off, but only slightly averted their bodies. They searched out and examined the holes by means of their antennæ, which were vibrating incessantly, and exploring on all sides. When they had selected a hole, they stationed themselves with the four anterior legs over it, and raising the body as high as possible, and the abdomen perpendicularly, bent the ovipositor downward in such a manner that it passed under the belly and thorax, and entered the hole over which they stood. It not unfrequently happened, when the hole was sufficiently large, that the whole abdomen was inserted, and the head, feet, and thorax were the only parts of the insects which remained free. Frequently also a contest took place between two females for the possession of a hole; but they did not employ their mandibles on these occasions, their fighting consisting entirely of violent concussions of their bodies, and strokes of the feet, till the weaker party retreated. When a female had obtained full possession of a hole, no attack could displace her; but she retained her seat even though assailed by a more powerful antagonist."

GENUS METOPIUS, Grav. Abdomen sessile, convex, rough; scutellum quadrangular, the apical angles acute; (ovipositor concealed).

M. *necatorius*, Grav.; *Peltastes necatorius*, Illiger, Curtis, *Brit. Ent.; Ichn. vespoides*, Panz. Lat. Length from five to seven lines. Face concave, the margins elevated, either entirely or the sides only yellow, sometimes with a broad black line or spot in the middle; palpi at times yellow or ferruginous. Antennæ filiform, a little shorter than the body, seldom entirely black, with the joints from the third to the fourteenth ferruginous beneath, gradually becoming more dusky; for the most part, however, all of them are ferruginous beneath, except the first, which is either entirely black or yellow on the under side. Thorax gibbous, clothed, especially on the sides, with a fine whitish down; a line before the wings, and another, or a spot, beneath them, yellow; sometimes also two spots on the back of the metathorax, and less frequently a lateral spot on the prothorax, and two small dorsal spots before the scutellum, of same colour. Scutellum seldom entirely black, the apical angles, and sometimes the whole apex, yellow. Wings of moderate size, smoky-hyaline, especially towards the radius, fulvo-hyaline towards the apex; stigma and radius ferruginous or fulvous; radix black, rarely testaceo-piceous; squamula black; areolet transversely triangular, somewhat irregular, sessile or sub-petiolate. Feet of moderate size, the posterior femora incrassate; coxæ black; trochanters generally black, with the apex yellow: the anterior femora usually black, with one of the sides more or less yellow or ferruginous; the middle femora sometimes with the apex only ferruginous, rarely black, with the base and apex yellow; the hinder femora generally yellow at the base, with the apex black, very rarely entirely black; the tibiæ yellow or ferruginous, the anterior rarely fuscescent on the outer side; the posterior with the apex more or less blackish, rarely black, with the inner side ferruginous: the tarsi flavo-ferruginous, or ferruginous, the posterior with the joints from the second to the fifth dusky. Abdomen twice the length of the thorax, scarcely narrower, cylindric, punctate; first segment very short, yellow, with the base, and sometimes a longitudinal line in the middle, black; the second with a yellow spot on both sides in the apical angle, sometimes obsolete; from the third to the fifth, and very rarely the sixth also, with the margins, yellow; the terminal segments occasionally somewhat blackish-blue.

This species appears to be pretty generally distributed. It is not unfrequent in England, where it has been observed to issue from the pupa of *Stauropus Fagi.* Mr Curtis conceives this insect to be one of the sexes of *M. dentatus.*

Hymenoptera Terebrantia.

Genus Bassus, Grav. Abdomen sessile, depressed; the first segment flat, of equal breadth; the terminal segments in the female sometimes compressed.

Sub-genus Bassus. Areolet either absent or triangular; antennæ and feet of moderate size or slender; (ovipositor sub-exserted, sub-erect).

B. *flavolineatus*, Grav. Length three lines. The head with a facial spot, the palpi and mandibles yellow, the latter with the apex black. Antennæ porrect, rather longer than the body. Thorax with the suture before the wings, and the lateral one between the prothorax and metathorax, together with a transverse line beneath the scutellum, yellow. Scutellum with the apex yellow. Wings smoky-hyaline, iridescent, the stigma and radius black-fuscous, the radius and squamula yellow. Feet rufous; the fore legs yellowish beneath, the base of the coxæ black; the hind legs with the tarsi and tibiæ black, the latter white at the base. Abdomen slightly depressed, the length of the head and thorax, and a little narrower; the first segment of equal breadth, one half longer than broad; the remainder transverse. Ovipositor very short, sub-exserted.

This species has been taken in England by the Rev. F. W. Hope, near Netley.

Genus Banchus, Grav. Abdomen compressed or sub-compressed, sessile or sub-petiolate.

Sub-genus Banchus. Abdomen sessile, rarely sub-sessile; areolet sub-rhomboidal, the lower external nerve of the interior cell sub-arcuate. (Ovipositor concealed).

B. *falcator*, Grav.; *Ich. venator*, Fab.; *Ich. falcatorius*, Fab. Gmel. Oliv. Panzer. Length from five and three fourths to seven lines. Mouth ferruginous, mandibles black at the base and apex, the external orbits of the eyes, rarely the internal also, yellow or ferruginous. Antennæ half the length of the body, or a little longer, slender and incurved towards the apex, beneath rufous or ferruginous, rarely fusco-ferruginous. Thorax gibbous, generally with a short sub-testaceous line below the insertion of the wings. Scutellum tuberculate, rarely sub-acuminate, sometimes ferruginous, very rarely yellow. Wings middle sized, fulvo-hyaline or somewhat smoke coloured; the stigma, radius, radix, and squamula fulvous, rarely ferruginous, the latter sometimes with a fuscous spot. Feet elongate, fulvous, for the most part yellow beneath, the coxæ black, occasionally with a ferruginous mark; the hinder tibiæ black at the apex, the tarsi ferruginous or ferrugino-fuscous. Abdomen longer than the head and thorax; the first segment gradually a little narrowed towards the apex, nearly one half longer than broad; from the first to the fourth segment narrower than the thorax, the back fusiform, the belly compressed; from the fifth to the seventh angular, the back, sides, and belly compressed; the first segment seldom wholly black, the apex being generally brown or rufous or fulvous; the second seldom wholly rufous, or black with a dorsal rufous spot, but most commonly brown or rufous with the base black, or the base rufo-ferruginous, the apex fulvous-yellow; the third with the back either entirely rufous, or the base black or the apex yellow, but more commonly black, with the base and a point at the apex rufous; the fourth sometimes, rarely also the fifth, sixth, and seventh, with the apex of the back, rufous.

The female of this species differs considerably from the male, particularly in the markings of the head and thorax. Neither of the sexes is rare, as they have been taken abundantly both on the continent and in England.

Genus Ophion, Grav. Abdomen compressed or sub-compressed, petiolate; antennæ filiform.

Sub-genus Paniscus. Abdomen sub-petiolate compressed, the back carinate; areolet triangular; the feet and antennæ somewhat slender; (ovipositor short).

P. *testaceus.* Length of the male from three to nine, of the female from three and three fourths to eight lines. The mandibles black at the apex, the face sometimes yellowish; the eyes and ocelli, sometimes also the hinder part of the head, fuscous or black. The antennæ for the most part obscure or fuscescent at the tip; in the male rarely fuscous or blackish, the base testaceous-ferruginous. Thorax sometimes with longitudinal fuscescent lines on the back. Wings hyaline or somewhat yellow-hyaline; the stigma testaceous or straw-coloured, in the male sometimes fuscescent, the radius fuscous or testaceous, the radix and squamula testaceous; areolet irregular sub-sessile, generally semi-complete, the lower portion of the exterior nerve obsolete. Feet fulvous, rarely ferruginous in the male, the hinder tarsi at times of a paler hue. Abdomen longer, sometimes by one half, than the head and thorax, compressed, the apex in the male obtuse, in the female truncate; testaceous, often fuscescent towards the apex, or somewhat fusco-fulvous towards the base; the sixth, seventh, and apex of the fifth segment, very rarely black-fuscous; the first segment gradually dilated towards the apex, five or six times longer than broad, the anterior portion nearly one half longer than the petiole. Ovipositor the length of a fifth or sixth part of the abdomen, black, the tube castaneous or fuscous.

This insect is of frequent occurrence throughout the south of Scotland in the autumn. It is likewise plentiful in England, and on the continent. It deposits its eggs on the larvæ of various moths, and occasionally on those of the genus *Tenthredo.*

Sub-genus Ophion. Abdomen petiolate, compressed, the back carinate; areolet absent, the interior cell receiving the two recurrent nerves; feet and antennæ slender, long; (ovipositor scarcely sub-exserted).

O. *luteus*, Grav. Fab.; *Ich. luteus*, Linn. Lat. Length of the male from six to nine, of the female from four to nine lines. The head in most individuals entirely rufous, or the internal orbits of the eyes yellow; rarely yellow, with the mouth and face, excepting the internal orbits of the eyes, rufous; very rarely entirely yellow; mandibles black at the apex: eyes and stemmata fuscous or blackish. Antennæ either a little longer or a little shorter than the body. Thorax testaceous or rufous, very seldom rufo-ferruginous, the prothorax with two longitudinal pale lines. Scutellum for the most part pale, sometimes yellow. Wings hyaline or somewhat smoky-hyaline; the stigma, radius, radix, and squamula fulvous or testaceous, the upper exterior nerve of the interior cell very seldom incrassate towards the stigma; in most instances, however, the rudiment of the nerve dividing the interior cell is observable, and it is sometimes produced as far as the middle, rarely beyond the middle of the cell. Abdomen testaceous, seldom rufous, the belly generally fuscescent, sometimes also fuscescent or blackish towards the apex. Ovipositor scarcely sub-exserted, blackish.

This species is pretty generally distributed over the western parts of Europe, and occurs not unfrequently in England. The female deposits her eggs on the larvæ of *Cerura vinula*, *Noctua præcox*, and other moths. "Ils y sont fixés," says Latreille, "au moyen d'un pedicule long et delié. Les larves y vivent, ayant l'extrémité postérieure de leur corps engagée dans les pellicules des œufs d'où elle sont sorties, y croissent, sans empêcher la chenille de faires sa coque; mais elles finissent par la tuer, en consumant sa substance intérieure, se filent ensuite des coques, les unes auprès des autres, et en sortent sous la forme d'ichneumons."[1] The larvæ of another species, *O. moderator*, Fab. destroy those of its ally *Pimpla strobitellæ*.

Genus Hellwigia. Abdomen petiolate, compressed; antennæ clavate.

H. elegans. Grav. Length from five to six lines. Head thick and closely punctate, with two deep irregular foveæ on the forehead, and a longitudinal groove between the antennæ; that of the male yellow, the occiput, foveæ, and apex of the mandibles black; that of the female black, the external orbits of the eyes yellow. Antennæ porrect, dilated at the apex a little more than half the length of the body, and composed of about thirty joints; in the male fulvous, yellowish on the under side towards the base, the first joint fuscous above; in the female rufous, the first three joints black. Thorax short, gibbous; two simple or hook-shaped spots before the neck, a short line under the anterior wings, two points or a single one under the posterior wings, a perpendicular line or point at the sides of the thorax, a point under the scutellum, a large semilunar spot on the metathorax, and another on each side of it, yellow: all these markings in the male are larger and more contiguous. Scutellum yellow. Wings middle-sized, hyaline, the stigma straw-coloured, the radius and nervures piceous or fuscous, the radix and squamula yellow. Feet middle-sized, sub-elongate; those of the male entirely yellow, the posterior tarsi rufescent towards the apex, the joints from the second to the fourth black at the base; the anterior feet of the female yellow, the coxæ black, with a small apical yellow spot, the trochanters black at the base; the hinder feet fulvous, the coxæ black, with a yellow spot, the trochanters yellow, the base black. Abdomen nearly one half longer than the head and thorax; the first segment flaggon-shaped, shining, very smooth, the anterior part scarcely longer than broad, shorter, and one half broader than the petiole; in the male the first segment black, the apex yellow, from the second to the fourth testaceous-rufous or yellow, with the base sub-rufescent, from the fifth to the seventh yellow, the fifth, and sometimes the sixth also, with the base, blackish at the side; in the female the first, fifth, sixth, and seventh segments black, with the margin yellow, the intermediate segments fulvous or rufous, with the margin for the most part yellow. Ovipositor scarcely sub-exserted, black.

The preceding examples will suffice to illustrate Gravenhorst's mode of treating the Ichneumonides. We shall now proceed to

Tribe 3d, Gallicolæ.[2]

These have only a single nervure on the lower wings; the upper pair offer a few areolets or cells, viz. two at the base—the brachial, of which the internal is usually incomplete or slightly marked,—one radial and triangular,—and two or three cubital,—of which the second, in such as have three, is always very small, and the third very large, triangular, and closed by the posterior margin of the wing. The antennæ are either of equal thickness, or increase towards the termination, but not club-shaped, and are composed of from thirteen to fifteen articulations, the number when different in the sexes being generally greater in the males. These insects form the old genus Cynips of Linnæus (Plate CCXXXI. fig. 20). Their general form is humped or gibbous, with the head small, and the thorax thick and elevated. The abdomen is compressed, carinated, or cutting inferiorly, and truncated obliquely, or obtuse, at the extremity. It is furnished in the females with an ovipositor, which seems to consist of only a single piece, long and delicate, or capillary, spirally rolled at its base, and attached near the origin of the abdomen. It is minutely described by Réaumur.[3] With this admirable instrument it deposits its eggs in the leaves and stems of various plants, and on these its punctures produce those peculiar excrescences known by the name of gallnuts, so useful when employed along with a solution of green vitriol, or sulphate of iron, in dyeing blacks. Some of these insects are apterous. "Une espèce," says Latreille, "dépose ses œufs dans la semence du figuier sauvage le plus précoce. Les Grecs modernes, suivant à cet égard une méthode que l'antiquité leur a transmise, enfilent plusieurs de ces fruits, et les placent sur les figuiers tardifs; les Cynips sortent chargés de poussière fécondante, s'introduisent dans l'œil des figues de ces derniers, en fécondent les graines et provoquent la maturité du fruit."[4] This is the process known abroad by the name of *caprification*.

The genera of this tribe are Ibalia and Figites, Lat. and Cynips proper (*Diplolepis* of Geoff.). Of the genus last named we have figured *C. rosæ*, its larvæ, and the gall in which the latter dwell (Plate CCXXXI. fig. 20, 22, 23, 26, 27, 28).

Tribe 4th, Chalcidiæ.

These do not differ very materially from the preceding, except in the antennæ, which, with the exception of *Eucharis*, are geniculate, and form, subsequent to the bend, an elongated or fusiform club, of which the first articulation is not unfrequently lodged in a groove. The palpi are extremely short. The radial cell is usually wanting, and there is never more than a single cubital cell, which is not closed. The antennæ have not more than twelve articulations. The modern genera are very numerous, though all related to the genus Chalcis of Fab. The species are extremely small, brilliantly ornamented with metallic colours. Many of them are leapers. The ovipositor is generally composed of three threads, like that of the Ichneumons, and is salient. The larvæ likewise resemble those of that tribe in being parasitical, and some of them are so minute as to be able to dwell at large in the interior of insect eggs, themselves scarcely visible to the naked eye.

We shall here mention only two genera of the tribe, of each of which we have figured an example. *Chalcis minuta* (Plate CCXXXI. fig. 25), synonymous with *Vespa minuta* of Linn., is extremely common on umbelliferous flowers. It is black, with yellow feet. Another species, *C. annulata*, Fab., inhabits the nest of the pasteboard wasp of South America (*V. nidulans*), and appears to have been mistaken by Réaumur for the female of that insect. Our other representative, *Leucospis dorsigera* (ibid. fig. 24), is black, with the abdomen almost as long again as the thorax, and marked with three bands and two spots of yellow. There is a transverse yellow line upon the scutellum, and two others of the same colour on the anterior portion of the thorax. The female deposits her eggs in the nests of mason-bees.[5]

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[1] *Règne Animal*, t. v. p. 287.

[2] We now resume the system of Latreille.

[3] *Mém. sur les Insectes*, t. iii. p. 483, et seq.

[4] *Règne Animal*, t. v. p. 292.

[5] For the other genera and species, see, besides, *Règne Animal* (t. v. pp. 295–9), Latreille's *Genera Crust. et Insect.* t. iv.; Klug's *Entomologische Monographien*; Dalman's *Analecta Entomologica*, and the Monographs and Memoirs of the same author; Maximilian Spinola's *Mémoire sur les Diplolépaires*; Mr Westwood on *Parasitic Hymenoptera* (*Phil. Mag.* 3d series, No. 3); Mr Halliday's *Essay* on the same subject in *Entom. Mag.* No. 3; Mr Walker's *Monographia Chalcidum*, published in the initiatory numbers of the last-named periodical; and a similar *Monograph* by M. Boyer de Foscolombe, in the *Ann. des Sciences Nat.* for July 1832.

TRIBE 5TH, OXIURI, Lat.

This tribe resembles the preceding so far as concerns the want of nervures in the lower wings, but the abdomen of the female is terminated by a tubular and conical ovipositor, sometimes internal and exsertile, proceeding like a sting from the anal extremity, sometimes permanently external, and forming a kind of tail. The antennæ are composed of from ten to fifteen articulations, and are in some cases filiform or slightly enlarged towards the extremity, in others clubbed in the females. The maxillary palpi in several are long and pendant.

The minor genera which compose this tribe are all more or less related to the genus BETHYLUS of Fabricius and Latreille. The only example we have here adduced is that of *Diapria elegans* (Plate CCXXXII. fig. 1), an insect belonging to a genus in which the wings have no cells. The maxillary palpi are projecting, and the antennæ have fourteen joints in the male, and only twelve in the female.[1]

TRIBE 6TH, CHRYSIDES, Lat.

This tribe agrees with the three preceding in the want of nervures in the lower wings; but the ovipositor of the female is formed by the terminal segments of the abdomen, which somewhat resemble in their construction the tubes of a telescope, and are terminated by a little sting.[2] The abdomen, which in the female seems to be composed of only three or four segments, is arched or plain beneath, and is capable of being applied against the chest,—in which attitude the insect assumes the form of a ball. This tribe includes the old genus CHRYSIS of Linnæus, and is remarkable for the extreme richness and brilliant lustre displayed by the colouring of many species. In these respects they rival the gorgeous humming-birds, and are known under the name of gilded wasps,—the *guepes dorées* of our continental neighbours. They are lovers of the cheerful sunshine, and during the bright days of early summer may be seen moving about in a state of great vivacity, almost of agitation, on walls, old timber, and other objects exposed to the gladdening influence of heat and light. They are also found on flowers, "beautifying the beautiful," and adding to their gorgeous petals all that is wanting to complete the glory of the "lilies of the field,"—a burnished or metallic lustre.[3]

The body of these insects is covered by a very solid integument. Their antennæ are filiform, geniculate, vibratile, and composed of thirteen articulations in both sexes. The mandibles are arched, narrow, and pointed. The maxillary palpi are usually longer than the labial, filiform, and composed of five unequal articulations;—the labial consist of three. The ligula is for the most part emarginate. The thorax is semicylindrical, and exhibits several impressed and transverse lines. The abdomen in the greater number is semi-oval, truncated at the base, and appears at first sight as if attached to the thorax by its entire breadth. The terminal segment is frequently marked by large punctures, and terminates in dentations.

These beautiful creatures deposit their eggs in the nests of the solitary mason-bees, and in those of other Hymenoptera. Their larvæ sustain themselves by devouring the lawful inhabitants.

In some, such as the genus PARNOPES, Lat. (Plate CCXXXII. fig. 2), the maxillæ and labrum are very long, and form a kind of false proboscis, bent underneath. The palpi are small and biarticulate. The example figured, *P. carnea*, deposits its eggs in the nest of *Bembex rostrata*. In CHRYSIS proper there is no false proboscis. The maxillary palpi are of medium size, or elongated, and composed of five articulations; the labial consist of three. Several analogous genera are recognised by naturalists, such as HEDYCHRUM, Lat. (Plate CCXXXII. fig. 3), in which the maxillary palpi are much longer than the labial, the ligula emarginate, and the abdomen rounded and entire at the extremity.[4]

ACULEATA.[5]

This, the second primary section of the hymenopterous order, is distinguished from the preceding by the want of an ovipositor. That organ is represented by a sting composed of three parts, concealed and retractile. It is characteristic of the females, and likewise exists in those individuals (imperfect in a sexual point of view) commonly called neuters, which constitute so important a feature in the social union of the gregarious kinds. It is, however, wanting in several of the ant tribe,—in which case the insect defends itself by ejecting an acid liquid, elaborated and contained in special reservoirs.[6] Our present Hymenoptera have always simple antennæ, composed of a constant number of articulations, that is, thirteen in the males and twelve in the females. The palpi are usually filiform; those of the maxillæ, which are frequently the longer, have six articulations,—the labial only four. The mandibles of the males are smaller, and generally less toothed, than in the others. All the wings are veined. The abdomen, united to the thorax by a thread or pedicle, is composed of seven segments in the males, and of six in the females.

The larvæ in this family are never furnished with feet. Their food is supplied to them by females or neuters, and varies in its nature according to the different kinds. Latreille divides the section into four families.

FAMILY I.—HETEROGYNA.[7]

The species of this family consist of individuals which differ from each other not only in their sexual characters, but in the presence or absence of the wings, and in other particulars. In all, the antennæ are geniculate, and the ligula small, rounded and hollowed, or spoon-shaped.

Some live in society, and consist of three kinds of individuals, of which two, that is, the males and females, are winged, and the third or neuters are apterous. In the two latter kinds the antennæ gradually increase in thickness, and the length of the first articulation equals at least the third part of their total extent; the second is almost as long as the third, and has the form of a reversed cone. The labrum of the neuters is large and corneous, and falls perpendicularly beneath the mandibles. These Hymenoptera comprise the genus FORMICA of Linnæus.

As a separate treatise under the article ANT[8] has been already devoted in this work to the elucidation of the history and habits of these admirable insects, so long noted for their foresight and industry, we shall not occupy our remaining space by repetition, but shall proceed to a brief sketch of the classification of the species, as promised at the conclusion of the article just referred to. Latreille divides the genus Formica as follows:—

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[1] For the other genera, see *Règne Animal*, t. v. pp. 300–2; *Genera Crust. et Insect.* t. iv.; Dalman's *Analecta Entomol.*; and Jurine's *Hyménoptères.*

[2] The details are given by Degeer in his *Mém. sur les Insectes*, t. ii. p. 834, pl. 28.

[3] In as far as we are competent to judge, plants and the mammalia seldom seem to exhibit a metallic surface. But that glowing adornment is frequent among foreign birds, and the subjects of our present treatise.

[4] See a *Monograph of the Chrysides*, by Pelletier de St Fargeau, in the *Ann. des Sciences Nat.* t. vii. p. 115.

[5] From *aculeus*, a sting.

[6] *Journal de Physique*, September 1828.

[7] From ἑτερος, *other* or *different*, and γυνη, *female.*

[8] See vol. iii. p. 239.

1*st*, The genus FORMICA properly so called. These want the sting; the antennæ are inserted near the front; the mandibles are triangular, dentated, and incisive; and the pedicle of the abdomen is never composed but of a single squama or knot.

Of the European species we may mention *F. rufa*, Lat., of which the workers measure about four lines in length, and are of a blackish colour, with a great part of the head, the thorax, and the knot, fulvous. The thorax is uneven. The stemmatic eyes are discernible. This species builds in woods, and forms a dome-like or sugar-loaf shaped habitation of considerable size, composed of earth and fragments of wood, &c. Formic acid is obtained chiefly from this insect. The winged individuals make their appearance in spring. (Plate CCXXXII. fig. 4.) *F. sanguinea*, Lat., resembles the preceding in its workers; but the colour is sanguine red, with an ashy-black abdomen. It likewise dwells in woods, and is one of the species named Amazons or *légionnaires* by M. Huber. *F. cunicularia*, Lat., has the head and abdomen of the workers black. Around the mouth, the under parts of the head, the first joint of the antennæ, the thorax, and feet, pale fulvous. The worker of *F. fusca*, Linn., is of an ashy-black, shining, with the base of the antennæ and the feet reddish. The squama or knot is large, almost triangular, and there is an appearance of three stemmatic eyes. Both these species are attacked by the Amazons, carried off, and enslaved.

2*d*, The genus POLYERGUS, Lat. In these the sting is likewise wanting; but the antennæ are inserted near the mouth, and the mandibles are narrow, arcuated, or strongly hooked. In this genus is placed the *F. roussatre* of Lat. so common in France. It is this species which is more particularly named Amazon by M. Huber the younger.

3*d*, The genus PONERA, Lat. In these the workers and the females are armed with a sting. The pedicle of the abdomen is formed of a single scale or knot; the antennæ of the individuals just mentioned are thickened towards the extremity; the mandibles are triangular, and the head is also nearly of that form, without remarkable emargination at its posterior extremity. *F. contracta* of Lat., which occurs near Paris, belongs to this division. The worker seems scarcely provided with eyes, and lives under stones in not very numerous groups. It is very small, black, nearly cylindrical, with the antennæ and feet of a yellowish brown.

4*th*, The genus MYRMICA, Lat. In these there is also a sting; but the pedicle of the abdomen is formed of two knots. The antennæ are exposed, the maxillary palpi are long, with six distinct articulations, and the mandibles are triangular. Such is the *fourmis rouge* of Latreille, of which the worker is reddish, finely chagrined, with the abdomen smooth and shining. There is a spine upon the first knot of the pedicle, and the third segment is brownish. This species occurs in woods, and bites sharply.

5*th*, The genus ATTA of Fabricius, which scarcely differs from Myrmica, except by its very short palpi, of which the maxillary are composed of less than six articulations. The head of the workers is usually very large. The species which serves as the type of the genus in the works of Fabricius, Jurine, and Latreille, is the *fourmis de visite*, or *Atta cephalotes* of systematic writers. It is a foreign insect, and seems to agree with that figured by Madame Merian.[1] This creature burrows in the earth, to the extent, it is said, of six or eight feet. It however leaves its subterranean dwelling for a time once a year, and enters dwelling-houses, where it attacks and destroys every other kind of inconvenient insect. If during these predatory incursions they find an intervening space which they cannot cross, a party volunteer to form a chain of their own bodies linked together, over which, as by a bridge, the main body passes.

6*th*, The genus CRYPTOCERUS of Lat., of which the species are also furnished with a sting, and have the abdomen of the pedicle formed of two knots; but the head, which is large and flat, has a groove on each side for the reception of a part of the antennæ. They are peculiar to South America.[2]

The other Heterogyna live in solitude, and each species is composed of only two kinds of individuals, winged males and apterous females,—the latter always provided with a strong sting. The antennæ are filiform or setaceous, vibratile, with the first and third articulations elongated; the length of the former, however, never equalling that of the third part of the total length of the antennæ. They form the genus *Mutilla* of Linnæus, which has been subdivided into DORYLUS, Fab. (Plate CCXXXII. fig. 6), peculiar to Africa and the East Indies; LABIDUS, Jurine, proper to South America; and MUTILLA properly so called (ibid. fig. 5). Of the latter, *M. Europæa*, Linn., is black, with a red thorax, and three white bands on the abdomen. The female is armed with a powerful sting. The manners of the Mutillæ seem little known. We are not ourselves acquainted with the nature of their metamorphosis. They love warm sunny places, and sandy soils. The females being apterous, are always found pon the ground, concealed under stones, or lurking in little holes. The males are seen on flowers, or by the sides of dusty paths, and other places frequented by the females. The genus is extensive, Olivier and Klug having described a great many species.[3]

FAMILY II.—FOSSORES.[4]

This family comprises such of the stinging Hymenoptera as are winged in both sexes, and of solitary habits. The legs of several are adapted for digging. The ligula is always more or less widened at the extremity, and never filiform or sectaceous. The wings are always extended. The old genus SPHEX is the principal representative of this family.

The females of these insects deposit their eggs in little prepared chambers in the earth or in wood, and place alongside of them a supply of insects or their larvæ. They also pierce spiders with their stings, and close them up as provision for their young. The larvæ are without feet, and spin a cocoon before passing into the nympha state. The perfect insects are in general extremely active, and live among flowers. The maxilla and the labium are elongated, and assume in several the form of a trunk. The numerous minor genera derived in recent times from the genus just named, are distributed by Latreille into seven principal tribes.

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[1] *Insectes de Surinam*, ed. of 1726, p. 18, tab. 18.

[2] Besides the article ANT of this work, see the noted volume by Huber the younger, entitled *Recherches sur les Mœurs des Fourmis indigènes*, and Latreille's *Histoire Naturelle des Fourmis*.

[3] In *Encyclop. Méth.* and *Act. Phys. Med. Acad. Cæsar. Leopold*, t. x. pars 2. Latreille has also published a monograph of the French species in the *Actes de la Soc. d'Hist. Nat. de Paris*, and a great number are figured by Coquebert in his *Iconographia Insectorum*.

[4] From *fossor*, a digger.

In the first two the eyes are often emarginate. The body of the males is usually narrow, elongated, and terminated posteriorly, in a great number, by three spinous points or dentations.

TRIBE 1ST, SCOLIETES, Lat.

The first segment of the thorax is sometimes in the form of a bow, and prolonged laterally as far as the wings, sometimes of a transverse square, or resembling a knot or articulation. The legs are short, thick, very spiny or ciliated, with the thighs arched near the knee. The antennæ are sensibly shorter than the head and thorax in the females. The genera are TIPHIA, Fab. (Plate CCXXXII. fig. 7); MYZINE, Lat.; MERIA, Illiger; and SCOLIA, Fab. (ibid. fig. 8).[1]

TRIBE 2D, SAPIGYTES.

The first segment of the thorax is formed like that of the preceding group, and the legs are also short, but slender, and neither spiny nor strongly ciliated. The antennæ in both sexes are at least as long as the head and thorax. The body is usually either smooth, or but slightly pubescent. The genera are THYNNUS, Fab.; POLOCHRUM, Spinola; and SAPYGA, Lat.

TRIBE 3D, SPHEGIDES, Lat.

These still resemble the preceding in the extent and form of the first segment of the thorax; but the posterior legs are at least once again as long as the head and thorax. The antennæ are often slender, formed of lengthened articulations, lax, or not compactly set, and curved or arcuated, at least in the males.

Of this tribe a certain number have the first segment of the thorax of a square form, whether transverse or longitudinal, and the abdomen is attached by a very short pedicle. The inner side of the posterior tibiæ is usually furnished with a brush or pellet of hairs. The upper wings have three or two complete or closed cubital cells, and a terminal one which is imperfect. The genera are PEPSIS, Fab. (Plate CCXXXII. fig. 9), of which the species, abundant in South America and the Antilles, are large, with coloured wings; CEROPALES, Lat.; POMPILUS, Fab. (ibid. fig. 10), of which the species feed their young with spiders; PLANICEPS, Lat.; and APORUS, Spinola.

Others of the same tribe have the first segment of the thorax narrowed in front, in the form of a knot or joint; and the first segment of the abdomen, and sometimes even a portion of the second, narrowed into an elongated pedicle. The upper wings always exhibit three complete cubital cells, and the commencement of a fourth. The genera are, AMMOPHILUS, Kirby, of which we may mention, as an example, *Sphex sabulosa*, Linn., the female of which digs holes in the earth by the sides of paths and highways, in which she deposits a caterpillar mortally wounded, and then lays an egg beside it,—the said egg soon producing another larva, which, though much smaller, being in good health, immediately eats the sick one; SPHEX, PRONÆUS, CHLORION,[2] and DOLICHURUS, Lat.; AMPULEX, Jur.; PODIUM and PELOPÆUS, Lat.

TRIBE 4TH, BEMBECIDES, Lat.

In these the first segment of the thorax forms only a linear and transverse border, of which the two lateral extremities are distant from the origin of the upper wings. The legs are always short, or of moderate length. The head, seen from above, appears transverse, and the eyes extend as far as the exterior border. The abdomen forms an elongated semi-cone, rounded on the sides, near the base. The labrum is entirely exposed, or very salient.

Of this tribe the species are characteristic of the warmer countries of the earth. Their body is elongated, pointed posteriorly, almost always varied with black and yellow, or reddish, and smooth. The antennæ are approximate at the base, slightly geniculate at the second article, and enlarged towards the extremity. The mandibles are narrow, lengthened, dentated on the inner side, and crossed. The tibiæ and tarsi are provided with little spines or cilia, which are particularly obvious on the anterior tarsi of the females. There are frequently one or two raised teeth beneath the abdomen of the male. The flight of these insects is extremely rapid, and they dart from flower to flower with a sharp and interrupted sound. Several species smell of the odour of roses.

In a certain number we find a false trunk, bent underneath, with the labrum in the form of an elongated triangle.

Of these, some have the palpi very short; the maxillary possessing four, the labial two articulations. Such is *Bembex rostrata*, Fab. (*Apis rostrata*, Linn.), Plate CCXXXII. fig. 11, a large black insect, with transverse bands of citron yellow upon the abdomen. This is a well-known European species. The female digs deep holes in a sandy soil, in which she places the carcasses of other insects, especially Syrphi, and other two-winged flies. Among these she lays her eggs, and then places a plug in the hole. Another hymenopterous insect, however, *Parnopes carnea*, possesses a strong instinctive desire to deposit her eggs in the subterraneous nest of the Bembex. As soon as the latter perceives its natural enemy hovering around its dwelling, it attacks it with the greatest fierceness, and endeavours to thrust its sting through its body,—an attempt, however, which is seldom successful, owing to the hardness of the Parnopes's skin. Others have the maxillary palpi elongated, and with six articulations,—the labial with four. Such is the genus MONEDULA of Lat.

In the remainder of this family there is no false trunk, and the labrum is short and rounded, *e. g.* the genus STIZUS of Jurine.

TRIBE 5TH, LARRATES, Lat.

These in their general aspect resemble the preceding, but their labrum is either entirely or in great part concealed, and there is a deep emargination on the inner side of the mandibles,—a character which distinguishes them both from those which precede and those which follow.

In some the upper wings have three closed cubital cells, of which the second receives the two recurrent nervures. Such are the genera PALARUS, Lat., LYROPS, Illiger, and LARRA, Fab. (Plate CCXXXII. fig. 13). In others the upper wings have only two closed cubital cells, each of which receives a recurrent nervure. Such are DINETUS and MISCOPUS, Jurine.

TRIBE 6TH, NYSSONES, Lat.

In this family the labrum is likewise entirely or in great part concealed. The maxillæ and labium do not form a trunk, and the mandibles have no emargination on the inner side. The head is of ordinary size, and the abdomen is triangular or ovoid-conical, becoming gradually narrower from the base towards the extremity, and never borne upon a long pedicle. The antennæ are filiform, with the first articulation slightly elongated.

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[1] For the anatomy of the Scoliæ, see Dufour's Observations in the *Journal de Physique* for September 1818.

[2] For the singular habits of *C. compressum*, common in the Isle of France, where it attacks, slays, and carries off cockroaches to its young, see Sonnerat's *Voyage aux Indes Orientales*; Réaumur's *Mémoires*, t. vi. p. 280; or the *Dict. Class. d'Hist. Nat.* t. iv. p. 42.

In the genera Astata, Nysson, Oxybelus,[1] and Nitela, Lat., the eyes are entire; in Pison of Spinola they are emarginate.

Tribe 7th, Crabronites, Lat.

In this, the concluding tribe of Fossores, the head is usually very large, and when viewed from above seems almost square. The antennæ are often enlarged towards the extremity, or club-shaped. The abdomen is either oval or elliptical, and broadest about the middle,—or narrowed at the base into a lengthened pedicle, and as if terminated by a club.

In some the antennæ are inserted beneath the middle of the anterior part of the head, and the chaperon is short and broad. In the genus Trypoxylon, Lat. the eyes are emarginate. Of these, one of the most remarkable is *T. figulus* (*Sphex figulus* of Linn.), Plate CCXXXII. fig. 13. The female deposits her eggs in holes in old timber, along with a supply of little spiders, which she closes up with moist earth. In the remainder the eyes are entire. In the genus Crabro of Fab. (ibid. fig. 15) many of the males are remarkable for a peculiar dilatation of the anterior tibiæ, resembling a slender shell, convex without and concave within, and pervaded by a multitude of little holes, or rather of transparent points. They somewhat resemble the well-known expansions on the fore-feet of the male Dytisci, and probably serve for the same end.[2] In the perfect state these insects seem to feed on the nectareous juices of flowers; but the larvæ are extremely greedy of animal food. The female parent forms holes in the earth, in each of which she deposits an egg along with the body of a captured insect. She then, as usual, closes up the orifice, and the entombed prey, whether dead or alive, is soon attacked and eaten by the young larva to which the egg gives birth. Dipterous insects form their most frequent food, although *C. cribrarius* is observed to seize upon the caterpillar of a *Pyralis* which inhabits the oak. Walckenaer observed several species hovering incessantly around the nests of a solitary bee named *Halictus terebrator*, which they seemed much inclined to enter.[3] The remaining genera of this division of the Crabronites are Stigmus, Jur.; Pemphedron, Lat., of which *P. unicolor* feeds its young on Aphides; Mellinus, Fab. (Plate CCXXXII. fig. 16); and Alyson, Jurine.

In other Crabronites the antennæ are inserted higher up or towards the middle of the face, and are usually enlarged towards the termination, or even club-shaped. In the genus Psen of Lat. the clypeus is almost square, and the abdomen is borne upon an abruptly formed and elongated pedicle, composed of the first segment. The mandibles terminate in two teeth. In Philanthus of Fab. the clypeus is trilobed, and the first segment of the body is at most restricted in the manner of a knot. The mandibles terminate in a simple point. The females of this genus dig holes in the sand, in which they bury the carcasses of bees, Andrenæ, and even of Curculionides, for the nourishment of their young.[4]

FAMILY III.—DIPLOPTERA.[5]

This is the only family of the section in which the upper wings are longitudinally folded.[6] The antennæ are generally geniculate, and clubbed, or enlarged towards the extremity. The eyes are emarginate. The prothorax is prolonged posteriorly on each side to the origin of the wings, of which the superior have three or two closed cubital cells, the second of which receives the two recurrent nervures. The body is smooth, or nearly so, black, and more or less spotted with yellow or fawn colour. Many of the species dwell in temporary societies, composed of three kinds of individuals, males, females, and workers or neuters. A few females which have withstood the rigour of the winter season commence the building of the nest, and attend to the young first produced, which are usually neuters—and these speedily aid their parent in all matters of household management. The family is composed of two tribes.

Tribe 1st, Masarides.

In these the antennæ seem at first sight to be composed of only eight articulations; the eighth forming with the ensuing ones an almost solid mass, rounded or obtuse at the end, with the articulations indistinct. The ligula is terminated by two threads capable of being withdrawn within a tube formed by its base. The upper wings have only two complete cubital cells. The middle of the anterior margin of the clypeus is emarginate, and receives the labrum in that emargination. The genera are few in number. In Masaris proper (Plate CCXXXII. fig. 17), the antennæ, a little longer than the head and thorax, have the first article lengthened, and the eighth forming an obconic club, rounded at the extremity. The abdomen is long. In Celonites, Lat. the antennæ are scarcely longer than the head, and their first two articulations are much shorter than the third; the eighth and following form an almost globular body. The abdomen is scarcely longer than the thorax.

Tribe 2d, Vespiariæ.

In these the antennæ always exhibit distinctly thirteen articulations in the male and twelve in the female, and terminate in an elongated mass, pointed, and sometimes hooked (in the males) at the end; they are always geniculate, at least in the females and neuters. The ligula is sometimes divided into four plumose filaments, sometimes into three lobes, having four glandular points at the end, one on each lateral lobe, and the two others on the intermediate one, which is larger, widened, and emarginate or bifid at the extremity. The mandibles are strong and dentated. The clypeus is large. Beneath the labrum there is a little piece in the form of a ligula, analogous to that which Réaumur observed in certain bees (bourdons), and which M. Savigny names *epipharynx*. With the exception of a small amount of species, the upper wings have three complete cubital cells. The females and neuters are armed with a very strong and venomous sting. Several species live in societies composed of three kinds of individuals.

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[1] The Oxybeli lay their eggs in little nests in sandy soils exposed to the sun. They store up a collection of dead flies for the use of their young.

[2] See Degeer, *Mémoires*, t. ii. p. 810, pl. 28.

[3] *Mémoires pour servir à l'Histoire Naturelle des Abeilles solitaires.*

[4] We have been under the necessity of doing little more than indicate the names of the generic groups in the family of Fossores. For the details the reader is referred to the corresponding articles in the *Encyclop. Méth.* and the *Diction. Class. d'Hist. Nat.*; to the *Règne Animal*, t. v. pp. 316–32, and more particularly to M. Van der Linden's *Observations sur les Hyménoptères d'Europe de la Famille des Fouisseurs.*

[5] From διπλόος, *double*, and πτερα, *wings*, in reference to the *folding* of these organs.

[6] The character however is not universal,—the genus *Ceramius*, Lat. of which Klug has published a monograph, forming an exception.

The larvæ of these insects are without feet, and each is enclosed in a cell where it is fed, according to its kind, either on the bodies of insects carried thither by the mother at the period of oviposition, or on the nectar of flowers, the juices of fruits and of animal matter, elaborated in the stomach of the parent, or in that of the workers, and carefully supplied from day to day. This tribe corresponds to the genus *Vespa* of Linn.

The genus CERAMIUS of Lat. differs from all the others in having the superior wings stretched or extended, and in the amount of the cubital cells, of which there are only two. The labial palpi are moreover longer than those of the maxillæ. The species occur in South Africa, and the warmer regions of Europe.[1]

In all the following genera the superior wings are folded, and present three complete cubital cells.

Sometimes the mandibles are much longer than broad, and approximate anteriorly in the form of a rostrum. The ligula is narrow and elongate. The clypeus is nearly heart-shaped or oval, with the point anterior, and more or less truncate. All the species are solitary, and each is composed of only males and females. The latter provision their young both before their birth and during the continuance of the larva state. Their nests are usually formed of earth, and are either concealed in the holes of walls, beneath the ground, in old wood, or are external, and placed on plants. Each nest contains a supply of caterpillars or other larvæ, which the female piles up in a circular form. She sometimes also stores up spiders, which she has the precaution previously to pierce with her sting.

In the genus SYNAGRIS, Lat. the ligula is divided into four long plumose filaments, without glandular points at their extremity. The mandibles of some of the males are very large. The species are few in number, and characteristic of Africa. In EUMENES, Lat. the ligula is divided into three portions, glandular at their extremity. The abdomen in some is ovoid or conical, and thicker at the base. Such are PTEROCHILE of Klug, remarkable for the great length of the labium and maxillæ, and for their labial palpi beset with long hairs, and composed of only three distinct articulations. In ODYNERUS, Lat. those parts of the mouth are much shorter, the labial palpi are nearly smooth, and consist of four perceptible divisions. *Vespa muraria* of Linn. belongs to this genus. It is described by Réaumur.[2] The female perforates deep holes in sand, or in the plaster of walls, at the orifice of which she forms an outer tube, at first straight, afterwards recurved, and composed of an earthy paste, arranged in thick contorted threads. In the cavity of the interior cell she heaps up from eight to twelve little green larvæ of the same age, disposing them in beds one above another, in a circular form. After depositing her egg, she closes the mouth of the hole, and destroys the outward scaffolding. The abdomen in others has its first segment narrow and elongated in the form of a pear, and the second bell-shaped. Such is the genus EUMENES proper, of which *E. coarctata*, Fab. constructs a spherical nest of fine earth on the stems of plants. She fills it with honey, according to Geoffroy, and then deposits an egg.

Sometimes the mandibles, scarcely longer than wide, have a broad oblique truncation at their extremity. The ligula is short, or but slightly elongated. The clypeus is almost square. These insects constitute the genus VESPA, or wasps properly so called. They unite in numerous associations, composed of males, females, and neuters. The last two kinds detach particles of old wood or bark with their mandibles, reduce and moisten them to the consistence of a paste resembling paper or pasteboard in its nature, and construct nests containing horizontal combs suspended from above by one or more pedicles; on the inferior side there is a range of vertical cells in the form of hexagonal and truncated pyramids. These cells serve solely as lodgings for the isolated larvæ and nymphs. The amount of combs forming the same nest varies; and the nest itself is sometimes open or exposed, sometimes surrounded by an envelope, pierced by a common and almost always central opening, which corresponds with a string of holes for the purposes of internal communication, if the edges of the combs adhere to the inner side of the external covering. These singular constructions are sometimes suspended to the branches of plants in the open air, sometimes concealed beneath the earth or in the hollows of old trees. Their form likewise varies according to the species.

The females commence their labours in spring, and in the first place in a state of solitude. In a nest of small dimensions they deposit the eggs of neuters or workers, which, as soon as they are hatched and attain maturity, enlarge the dwelling, and assist in rearing additional members of the body politic. For a considerable time the society consists only of the original founder of the colony, that is, the female parent, and of neuters. Towards the end of summer or beginning of autumn, young males are hatched, along with additional females. But all such larvæ and nymphs as have not completed their final metamorphosis before the month of November are murdered by the neuters, and torn from their cells. These destroyers are themselves ere long destroyed, in common with the males, by the first frosts of winter. The latter sex never work. A few females alone survive the rigours of the winter season, and these again, on the return of spring, become each the founder of a new but equally transitory empire. Of the death and desolation which is so soon to overtake their busy race, the *genus irritabile* is, however, all unconscious during the glad summer days, or those of the *fruitful* autumn, in which they ply their never-ceasing labours:—

> So fails, so languishes, grows dim, and dies,
> All that this world is proud of;

and hymenopterous and human kingdoms, alike decay and perish. The polity of wasps, we may observe, is not so exclusively monarchical as that of bees. It partakes rather of the republican order, as many females dwell together in amity during the autumnal season. These Vespæ are almost omnivorous. They prey on other insects, on flesh and fruits of every kind, especially when ripe and sweet. They appear to an uninstructed eye as very gluttonous; but their apparent greed becomes more excusable, when we consider that they are catering, not for themselves, but for a numerous and otherwise unprovided offspring. The larvæ, in consequence of the peculiar position of the opening of their cells, lie in a reversed position, with their heads downwards. When about to pass into the nympha state, they shut up their cells, and fabricate a cocoon.

In several species, that portion of the inner margin of the mandibles which is beyond the angle, and terminates it, is shorter than that which precedes the angle. The central part of the front of the clypeus is pointed. These belong to the genus POLISTES of Lat. and Fab. in which we class *P. morio* from Cayenne. Its nest is large, in the form of a truncated cone, pierced inferiorly and at one side. It is composed of very thick pasteboard. Here also are placed the *Vespa gallica* of Linn. and the *V. nidulans* of Fab. *P. Lecheguana*[1] is a species which we owe to M. Aug. St Hilaire, who brought it from the interior of Brazil. Its combs contain an excellent honey, resembling in consistence that of our own domestic species, but possessing at times the singular quality of rendering those who eat it furious, or void of reason. It has been known from ancient times that common honey is occasionally possessed of very deleterious properties, arising probably from the nature or condition of the flowers from which it is collected. The naturalist just named, and two men by whom he was accompanied, nearly perished in consequence of eating of the Brazilian honey in its poisonous state.

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[1] See Klug's *Entomologische Monographien*, p. 219, et seq.

[2] *Mémoires*, vi. xxxvi. 1–10.

In other wasps the superior portion of the inner margin of the mandibles, or that which succeeds the angle, is as long if not longer than the other portion of that margin. The central part of the front of the clypeus is widely truncated. The abdomen is always ovoid or conical. These constitute the genus VESPA properly so called, of Latreille. The French entomologist here places the *V. crabro*, Linn., which we call the *hornet*. (Plate CCXXXII. fig. 18.) It builds its nest in sheltered places, such as barns, old walls, wooden posts, and hollow trees. It is of a roundish shape, composed of coarse materials, and resembles an old leaf in colour. This species devours other insects, and robs bees of their honey. Though a well-known English insect, it has not yet been found in Scotland. The common wasp, *V. vulgaris* (ibid. fig. 19), forms a somewhat similar nest; but it is composed of finer paper, contains a greater number of combs, and is sheltered in a hole in the earth. *V. media*, Lat. is intermediate as to size between the two preceding. It hangs its paper dwelling beneath the branch of a bush or tree. The nest of *V. holsatica*, Fab. is worthy of a brief record. It is almost globular, pierced at the top, and enclosed beneath in a kind of saucer. It is sometimes observed abroad, in barns, or attached to the beams of garrets, and has even been found in hives. It is not unknown in Britain.

FAMILY IV.—ANTHOPHILA,[2] LAT.

In this, the last family of the stinging Hymenoptera, we find a peculiar power existing in the two posterior legs,—that of collecting the pollen of flowers.[3] This character distinguishes our present groups from those of every other family of insects. The first articulation of the tarsi of the hinder legs is very large, compressed, and in the form of a square pallet, or of a reversed triangle. The maxillæ and the labium are usually very long, and constitute a kind of trunk. The ligula is generally shaped like the head of a lance, or resembles a lengthened filament, of which the extremity is silken or hairy. The larvæ are fed exclusively on honey, or the fecundating pollen of flowers. The perfect insects restrict their own diet to the nectareous juices of flowers, and (when Flora's kingdom has fallen before the approach of winter) to the secretion which they form from these, which we call honey. These Hymenoptera, embracing the great genus APIS of Linnæus, are divided by Latreille into two sections.

SECTION 1ST, ANDRENETÆ, Lat.

The genera of this section have the intermediate division of the ligula heart-shaped or lance-shaped, shorter than the sheath, and bent upwards in some, almost straight in others. They correspond to the *Pro-abeilles* of Réaumur and Degeer, the Andrenæ of Fabricius, and the Melittæ of Kirby.[4]

The Andrenetæ are solitary insects, and consist of only males and females. Their mandibles are simple, or terminated at most by two dentations. The labial palpi resemble the maxillary, and the latter have six articulations. The ligula is divided into three portions, of which the lateral are short, and in the form of auricles. The majority of the females collect the pollen of plants by means of the hairs of their hinder legs, and mixing it with a little honey they thus form a paste for the nourishment of their young. They form holes in the ground, frequently even in firmly-trodden places by the sides of roads, or in fields, and of considerable depth. In these they place their paste, and depositing an egg along with it, they close up the entrance with earth.

Some have the middle division of the ligula widened at the extremity, almost heart-shaped, and doubled in repose. Such is the genus HYLÆUS, Fab. which is now partitioned into two. In the first, or HYLÆUS properly so called (Plate CCXXXII. fig. 20), the body is smooth, the second and third joints of the antennæ of almost equal length, and the upper wings present only two complete cubital cells. The species being hairless, do not collect pollen, and seem to deposit their eggs in the nests of other Hymenoptera of this family. In the second genus, COLLETES, Lat. the body is hairy, the third article of the antennæ exceeds the second in length, and the upper wings present three complete cubital cells. The females collect their stores from flowers. Such is the *Apis succincta* of Linn.—"l'abeille dont le nid est fait d'espèces de membranes soyeuses," of Réaumur.[5] The male is distinguishable by his more lengthened antennæ. The female forms in the earth a cylindrical hole, of which the walls are endued with a gummy liquid, which has been compared to the viscous and shining slime left by slugs on the places over which they have passed. She then forms a number of thimble-shaped cells, apparently composed of the same material, placed end to end, and in a string, and each containing an egg and a suitable portion of paste.

Other Andrenetæ are distinguished from the preceding by the form of the ligula, which is lanceolate. In some of these, that part is folded on the superior side of the sheath, as in the genera ANDRENA and DASYPODA of Lat. (Plate CCXXXII. fig. 21). The females of the latter have the first joint of the tarsi very long, beset with lengthened hairs after the manner of a little feather. The upper wings in both these genera have only two cubital cells. The *Andrena flessæ* of Panzer, common in the environs of Paris, secretes a peculiar kind of honey, black and oily like the grease (cambois) used for carriage-wheels. It has a narcotic odour. In others the ligula is straight, or slightly bent underwards at its extremity. Such are the genera SPHECODES, HALICTUS, and NOMIA, of Latreille.

SECTION 2D, APIARIÆ, Lat.

In this second section of the honey-making Hymenoptera the genera are characterized by the middle division of the ligula being at least as long as the mentum or its tubular sheath, and setiform or filamentary. The maxillæ and labium are greatly elongated, and form a sort of trunk, geniculate and bent beneath while not in action. The two first articulations of the labial palpi have generally the form of a scaly and compressed seta, which embraces the sides of the ligula; the two others are very small, and the third is usually inserted near the exterior extremity of the preceding, which terminates in a point.

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[1] *Ann. des Sciences Nat.* t. iv. p. 339.

[2] From ανθος, *flower*, and φιλος, *lover*.

[3] Latreille remarks that the parasitical species are not possessed of this faculty;—but the form of their legs is essentially the same, those parts being merely destitute of the hairs or brushes.

[4] *Monographia Apum Angliæ.*

[5] *Mémoires*, vi. xii.

The Apiariæ are either solitary, or united in society.

A.

In the former, which constitute the first principal division, the species consist of only two kinds of individuals, of the ordinary nature of male and female. Each female provides, by her own unassisted efforts, for the preservation of her posterity. The posterior legs are unprovided with the silky down (la brosse) on the inner face of the first articulation of the tarsi; neither do we perceive that particular depression on the outer side of the tibiæ, which the French naturalists distinguish as *la corbeille*, or the basket, and which is so useful in the economy of the *workers* in certain other genera. That outer side, as well as the corresponding part of the first articulation of the tarsi, is usually furnished with numerous close-set hairs.

a.

The first subdivision of these solitary Apiariæ consists of species in which the second articulation of the posterior tarsi of the females is inserted in the centre of the extremity of the preceding one; the exterior and terminal angle of the latter does not appear dilated or more advanced than the interior.

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We shall first signalise a group of genera which have been named *Andrenoides*, no doubt from the resemblance which they bear to the latest of the preceding genera in their labial palpi, composed of slender linear joints, placed end to end, almost entirely similar to those of the maxillary palpi, and which are six in number. The labrum is always short. The females have no brush on the abdomen; but their posterior legs are clothed or garnished with tufts of hair, which serve them to collect the pollen of flowers. Some have the mandibles narrow, contracted towards the extremity, terminated in a point, and, in common with the labrum, smooth. Such are the genera Systropha, Illig. Rophites, Spinola, and Panurgus, Panzer. Others have the mandibles, in the females, almost spoon-shaped, very obtuse, carinated or grooved, and bidentated at the end. The labrum is very hard, and ciliated above. The antennæ are strongly geniculate and filiform. The upper wings have three complete cubital cells, the first intersected by a little transparent line, the second triangular, the third the largest, and receiving the two recurrent nervures. The genus Xylocopa, Lat. (Plate CCXXXII. fig. 22), resemble large humble-bees. Their body is usually black, sometimes covered in part with a yellow down, and the wings are frequently adorned by brilliant tints of violet, copper, and green. The males of several species differ greatly from the females. Their eyes are large, and more approximated superiorly. Their anterior legs are dilated and ciliated. The species figured, which is the *Apis violacea*, Linn. is one of the best known in European countries. The female excavates holes in old wood, divided into several cells, in each of which she deposits an egg, and a portion of paste for the sustenance of the future grub. The species are very numerous in foreign countries, and seem to spread over many regions of the globe. Comparatively few occur in Europe.

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In other genera the labial palpi appear under the form of scaly setæ; the first two articulations are very large, or much lengthened, compared to the last two, of a scaly consistence, with the margins membranous or transparent. The maxillary palpi are always very short, and have not unfrequently fewer than six articulations. The labrum in a great number is lengthened, inclined upon the mandibles, sometimes in the form of an elongated square, sometimes of a lengthened triangle.

The group named *Dasygastræ* by Latreille are remarkable, as their name implies, in this, that the abdomen of the female is almost always furnished with numerous short, close-set hairs, which form as it were a silky brush. The labrum is as long or longer than broad, and of a square form. The mandibles of the females are strong, incisive, triangular, and toothed. The paraglossæ are always very short, in the form of scales, pointed at the end. Of all the genera which compose this group, that called Ceratina approaches most closely to that of which we last figured an example; and, according to Maximilian Spinola, the habits of the females are identical with those of the Xylocopæ.[1] We have several species in Britain. All the remaining *Dasygastræ* have at most only four articulations to the maxillary palpi, and two complete cubital cells. In the six genera next ensuing, the abdomen is obviously furnished beneath with a silky brush. The species belonging to Chelostoma, Lat. and Heriades, Spin. form their habitations in the hollows of ancient trees. In the genus Megachile, Lat. the maxillary palpi are composed of only two articulations, the abdomen is plain above, and susceptible of being raised upwards,—thereby enabling the female to use her sting over her body. This genus contains several singular insects, of which the habits have been well described by Réaumur and other observers.[2] *M. muraria* is one of the largest of the genus. The female is black, with dark wings tinted with violet; the male is covered with reddish hairs, the terminal segments of the abdomen being black. The former sex constructs her little nest on walls and stones in sunny places. It is made of fine earth worked into a kind of mortar, which drying, becomes very hard and durable. On this account the term *mason-bee* is applied to this insect, and to several other species of analogous habits. The interior of these nests contains about a dozen cells, in each of which the provident parent deposits an egg and a piece of paste. The perfect insect is not produced till the spring of the ensuing year. Another species, *M. sicula*, Lat. is black and hairy, with the front, the upper part of the thorax, and the legs, bright yellow. The female constructs a hard and spherical nest, of rather more than an inch in diameter, which she attaches to the branches of heath and other plants. This insect occurs both in Egypt and the south of Europe, and was lately noticed in Corsica by M. Payraudeau. The habits of other species of the genus Megachile are very different from those just noted. They are known by the name of *leaf-eating bees* (Plate CCXXXII. fig. 23), on account of their employing in the construction of their nests perfectly oval or circular pieces of leaves, which they cut out with the most remarkable dexterity. These pieces are conveyed to their straight cylindrical holes, which they previously excavate in the earth, or sometimes in walls, or the decayed trunk of an old tree. They line the bottom of the cavity with these cuttings, and form a thimble-shaped cell (ibid. fig. 27), in which they deposit the honeyed provision on which the larva is destined to feed. After laying an egg, they close the cell by means of a flattish or slightly concave lid, also formed of a portion of leaf. These little cells are repeated one over the other till the hole is filled up. To this division of the genus belongs the *M. du rosier* of Lat. (*Apis centuncularis*, Linn.). The genus Lithurgus, Lat. is furnished with four articulations to the maxillary palpi, and the abdomen is depressed above. All the articulations of the labial palpi are placed end to end. The females have a rounded projection in the middle of the head. Such are *Centris cornuta*, Fab. and an unpublished species from the Isle of France, alluded to by Latreille. In the genus OSMIA of Panzer the maxillary palpi consist of four articulations, or at least of three very distinct ones, and the abdomen is convex above. The habits of the species have been observed by Réaumur, Degeer, Spinola, and other naturalists. Several are *masons*, and have frequently two or three horns on the clypeus, which are probably of use in the construction of their nests. These are concealed in the earth, in chinks of walls, door-posts, and old wood, and sometimes even in the shells of snails (*Helices*). One of the most interesting of the genus is the *Osmia papaveris*, which lines its subterranean dwelling with the gorgeous petals of the scarlet poppy. Another, *O. gallarum*, takes possession of a fungous gallnut formed by a kind of Cynips which inhabits the oak. The hollow space left by the Cynips being too small, the little bee enlarges it considerably, and polishes the interior. The genus is composed of about thirty species, which seem almost peculiar to Europe. A considerable number occur in Britain. The other genera of this group are ANTHIDIUM, Fab., STELIS, Panzer, and COELIOXYS, Lat.[1] The two last-named genera of Dasygastræ resemble the ensuing group in wanting the silky brush, from which it has been presumed that they also coincide with them in being parasitical; but their labrum is parallelogramic, and the mandibles are triangular and dentated. The maxillary palpi are very short and bi-articulate.

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[1] See the article *Ceratine*, in the 2d edition of the *Nouv. Dict. d'Hist. Nat.*

[2] *Mémoires*, t. iv.

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A third group of genera in this subdivision of the (solitary) Apiariæ is named *Cuculinæ*. They resemble the preceding in the posterior tarsi, and agree with the concluding genera in the labial palpi being in the form of squamous setæ; they also resemble the genera *Stelis* and *Coelioxys* in the abdomen being destitute of a silky brush. They are parasitical, and their bodies are almost smooth and coloured like those of wasps, sometimes partially clothed or hairy. The labrum assumes the form of a lengthened and truncated triangle, or is short and almost semicircular. The mandibles are narrow, ending in a point, and at most unidentated on the inner side. The paraglossæ are often long, narrow, and setiform. The scutellum in several is emarginate or bidentated; in others it is tubercular. These insects correspond to the *Nomadæ* of Fabricius. Several appear in those countries to which they are indigenous, flitting about in spring partly near the ground, or on walls exposed to sunshine. They are then employed in searching for the nests of other Apiariæ, in which they, cuckoo-like, deposit their eggs. It was in reference to this habit that Latreille named them Cuculinæ. The genera are AMMOBATES, PHILEREMUS, EPEOLUS, Lat., NOMADA, Fab. (Plate CCXXXII. fig. 24), PASITES, Jur., MELECTA, Lat., CROCISA, Jur., OXÆA, Klug.[2] Of these, Nomada is the richest in British species. The genus occurs in Asia, Africa, and America, although the majority are characteristic of, if not peculiar to, Europe. The genus Melecta is not unknown in Britain.

b.

The concluding subdivision of the solitary bees is characterized by the first article of the posterior tarsi being dilated inferiorly on the outer side, so that the following articulation is inserted nearer to the internal angle of its extremity than to the opposite one. The outer side of that first angle, as well as the corresponding part of the tibiæ, is furnished with thick and close-set hairs, forming, especially in several exotic species, a sort of brush or tuft,—and thence the name of *Scopulipedes*, bestowed on this division by Latreille. The under part of the abdomen is naked, or at least unprovided with a silken brush. The number of cubital cells is three, with few exceptions, and each of the last two cells receives a recurrent nervure.

Sometimes the maxillary palpi consist of from four to six articulations.

In a certain number the mandibles exhibit only a single tooth on the inner side. These species fly with great rapidity from flower to flower, and with a buzzing sound. They construct their nests either under ground, or in the clefts of old walls. Several prefer ground which has been cut perpendicularly, and exposed to the sun. Those species in which the two lateral portions of the ligula are as long as the labial palpi, and setaceous, and of which the antennæ of the males are lengthened, form the genus *Eucera* properly so called (Plate CCXXXII. fig. 25). The male of a British species (*Apis longicornis*, Linn.) is black, with the labrum and the anterior extremity of the head yellow; its upper portion, thorax, and two first segments of the abdomen, are covered by a reddish down. The female (at one time described by Fabricius as a distinct species, under the name of *Apis tuberculata*) has short antennæ. The maxilla and labium form at their base a slight projection. The abdomen is marked by grey stripes, with a reddish termination. Several other species occur in Britain. Spinola has detached certain species, of which the maxillary palpi have only five distinct articulations, and the superior wings only two cubital cells. These he names MACROCERA.[3] The MELIPODES of Lat. may be defined as American Euceræ, with but four joints to the maxillary palpi, and three cubital cells to the superior wings. In the other Apiariæ of this subdivision, the paraglossæ are much shorter than the ligula, and always exhibit three cubital cells. In MELITTURGA and ANTHOPHORA, Lat. (of both of which several species are indigenous to Britain), the maxillary palpi have six articulations. In SAROPODA, Lat., likewise known among ourselves, the maxillary palpi have only five articulations, and those of the labium are continuous. Lastly, in the genus ANCYLOSCELIS, Lat., of which the species are native to Brazil, the maxillary palpi offer only four articulations.

In others the mandibles have several dentations on the inner side, and the maxillary palpi, as in the preceding genus, have four articulations. Such is the American genus CENTRIS of Fab.

Sometimes the maxillary palpi consist of only a single very small articulation, which even becomes imperceptible in certain species. The paraglossæ are very short, and the mandibles dentated. Such are the genera EPICHARIS and ACANTHOPUS of Klug.[4]

B.

Our second principal division of the Apiariæ is constituted by many interesting insects, such as the garden and humble bees, so remarkable for their peculiar *regime*, and the gregarious habits of the species, each of which consists of three kinds of individuals—males, females, and neuters, as the workers are often called. The posterior tibiæ of these last named are furnished on their external face with a smooth depression called the basket, in which they place the pollen collected from flowers by means of the silky down or brush with which the inner face of the first joint of the posterior tarsi is provided. The maxillary palpi are very small, and consist of a single articulation. The antennæ are geniculate.

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[1] See *Règne Animal*, t. v. p. 350.

[2] For the characters of the above genera, see *Règne Animal*, t. v. p. 352–3; and Kirby's *Monographia Apum Angliæ*. The haunts and habits of the species are noted under their generic titles in the *Encyclop. Méth.*, and the *Diction. Class. d'Hist. Nat.*

[3] The name is objectionable, either on Spinola's part or Meigen's (according to whoever used it last),—as we observe that the German author, in his *Zweiflügeligen Insecten*, applies the same title to a dipterous genus.

[4] See *Encyclop. Méth.* and other works already named.

Sometimes the posterior tibiæ are terminated by two spines, as in the genus Euglossa, Lat. (Plate CCXXXII. fig. 26), which has the labrum square, and the false proboscis, or prolonged parts of the mouth, as long as the body. The labial palpi terminate in a point formed by the two other articulations. The species are peculiar to South America. Latreille supposes that we owe to the one which we have here figured (*E. dentata*), and to that called *E. cordata*, the green honey so much esteemed in the Antilles. We are still ignorant of the habits of these insects. In the genus Bombus (ibid. fig. 29), the species of which we recognise in this country as *humble-bees*, the labrum is transverse, and the proboscis obviously shorter than the body. The second articulation of the labial palpi terminates in a point, bearing the two others on its outer side. There are few associations of our childhood more deep and lasting than those connected with the pursuit and capture of these beautiful creatures, some of which are remarkable for their size, and the rich contrast which they exhibit of velvet black and crimson, with bars of brilliant yellow. This splendid attire, however, saves them not from being rudely handled; and we remember the day when an artificial *bink*, that is, a little box made of clay, with a piece of glass at one end, and a sprinkling of sugar at the other, contained as many captives in proportion to its size, as the black-hole of Calcutta. But the practice of *blobbing* was one we never patronized, although we know it is pursued in this country, just as it seems to be, judging from the following quotation, by the youth of the *Great Nation*:—“Ils sont bien connus des enfans, qui les privent souvent de la vie pour avoir le miel renfermé dans leur corps, et le sucer.[1] The exciteable genius of a great English poet is roused to a wider range of sentiment and association by the sight of one of these industrious beings.

And is she brought within the power
Of vision?—o'er this tempting flower
Hovering until the petals stay
Her flight, and take its voice away!
Observe each wing—a tiny van!—
The structure of her laden thigh,
How fragile!—yet of ancestry
Mysteriously remote and high,
High as the imperial front of man,
The roseate bloom on woman's cheek;
The soaring eagle's curved beak;
The white plumes of the floating swan;
Old as the tiger's paw, the lion's mane
Ere shaken by that mood of stern disdain,
At which the desert trembles.—Humming-Bee!
Thy sting was needless then, perchance unknown;
The seeds of malice were not sown;
All creatures met in peace, from fierceness free,
And no pride blended with their dignity.
—Tears had not broken from their source,
Nor anguish strayed from her Tartarian den;
The golden years maintained a course
Not undiversified, tho' smooth and even;
We were not mocked with glimpse and shadow, then
Bright seraphs mixed familiarly with men,
And earth and stars composed a universal heaven.[2]

Be this as it may, the species of the genus Bombus inhabit subterranean dwellings, assembled together in social groups amounting to from fifty to sixty individuals, or even in certain cases to between two and three hundred. These unions, however, differ from those of the honey or garden-bee in this, that they are dissolved, like those of wasps, on the approach of winter. They consist of *males*, distinguished by the smallness of their size, their feebler heads, their narrower mandibles, terminated by two dentations, and bearded, as well as by their frequent difference of colour; of *females*, which are larger than the other individuals, and have spoon-shaped mandibles; and of *workers*, of which the mandibles are likewise spoon-shaped, and the size intermediate between the two preceding kinds. Of these workers, Réaumur was the first to distinguish two varieties,—one comparatively large and strong, the other smaller, but more lively and active. This curious fact was afterwards verified by Huber the younger. According to the observations of the Genevese observer, several of the workers born in spring couple during the month of June with males sprung from a common mother, and soon afterwards deposit eggs, from which, however, males alone are produced. These latter couple with the females which are born towards the end of the season, and which continuing through the winter in a pregnant state, become each the founder of a colony in spring. In the mean time, all the others perish, without excepting even the smaller females. The workers, then, though, in common with those of the garden-bee, often called neuters, are in fact females, but of smaller size than the more regular mothers, and with the productive faculty imperfectly developed. No sooner has the genial influence of spring penetrated the mossy cells where these more ponderous matrons have enjoyed their winter sleep, than they rouse themselves from their repose, and wing their dubious flight in search of the first opening crocus, or other garden flower; or, if remote from man, and destined to boom amid wild uplands or other pastoral wastes, the flowering *saughs* (*Salix caprea*), which so often skirt the edges of our mountain streams, and beautify the crystal waters by the reflection of their golden blossoms, afford them a sufficing food. The lover of nature knows how, even among sterile solitudes, a few bright sunny days call into life and beauty many fragrant flowers, not long unvisited by these glad labourers, who ere long settle in some fit abode, and lay the foundations of a future city.

The nests of humble-bees are generally formed beneath the earth, and at a depth of one or two feet. Dry plains, fields, sloping banks, and the sides of hills, are their common localities. These subterranean cavities are of considerable extent, wider than high, and in the form of a dome. The ceiling is constructed of earth and carded moss, carried thither fibre by fibre. The inner walls are plastered over by a coating of coarse wax. Sometimes a simple opening serves as a passage to the foot of the nest; sometimes a tortuous road, of one or two feet in length, leads to the habitation. The bottom of the cavity is lined with a layer of leaves, for the reception of the brood. The female first places in it masses of brown irregular wax, called *pâtée* by Réaumur, and compared to truffles by that naturalist, on account of their shape and colour. Their cavities are destined to contain the eggs and larvæ. The latter live together in society until such time as they are ready to assume the nympha state; they then separate and spin ovoid silken cocoons, vertically fixed against each other. The nymph is always found in a reversed position, or with the head downwards, like those of the females of the honey-bee; and the cocoons are uniformly pierced at their lower end when the perfect insect escapes from its prison. Réaumur asserted that the larvæ fed upon the wax which formed the walls of their habitations; but these, according to M. Huber, merely serve as a protection from cold and moisture; and the actual food consists of an ample provision of pollen moistened with honey, which the labourers provide for the helpless objects of their instinctive affection. When the supply is exhausted, they pierce the cover of the cells, put in an additional supply, and re-close the protecting habitation. We may truly observe, in relation to these delightful labours, that it is not alone in the "great waters" that man may behold the wonderful works of an omnipotent Creator; for literally the *earth* is "full of his goodness." These affectionate labourers, so pervaded by the instincts of maternity, though themselves for the most part barren, watch like rejoicing mothers over the destiny of the future citizens; and as soon as they perceive that a generous diet has increased their dimensions, they enlarge the size of their habitations. We find moreover in these nests three or four small bodies resembling goblets, composed of brown wax, or of the same consistence as the *pâtée*, always open, and more or less filled with good honey. The exact situation in the hive of these honey jars is by no means constant. It has been said that the workers make use of the empty cocoons for the same purpose; but their doing so is deemed very doubtful by Latreille, in as far as these cocoons are not only formed of a silky substance, but are perforated on the under side.

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[1] *Règne Animal*, t. v. p. 357.

[2] Wordsworth's *Vernal Ode.*

The larvæ are hatched in about five days after the deposition of the eggs, and accomplish their metamorphoses in the months of May and June. It was formerly supposed that labourers alone were produced at this period; but we have already alluded to the simultaneous production of a certain number of males. The labourers immediately proceed to assist the female founder in her operations; and from this period the number of cells which serve as habitations for the larvæ and nymphs is greatly augmented. They form irregular combs, rising in stages, on the edges of which the pâtée of Réaumur is particularly observable. According to Huber, the workers are extremely greedy of the eggs of the female, and sometimes in her absence open the cells in which they are deposited, in order to suck the milky fluid they contain! a most extraordinary fact, as Latreille observes, and one which seems to belie the noted attachment which they entertain for the germs of that race of which they are the natural and appointed guardians. The wax secreted by humble-bees is elaborated by the same peculiar process as that which produces the more beautiful material with which the garden species constructs its honeyed cells. It in fact results from honey, transuded through the intervals of the rings of the abdomen.[1] Several females dwell together in unity, and do not exhibit that instinctive aversion towards each other so remarkable among our domesticated species.

Yet these bees, however humble, have enemies, numerous and of various kinds. Their habitations are uprooted or otherwise attacked by foxes, badgers, weasels, polecats, rats, field-mice, ants, and moths. Certain *Volucellæ* (*Syrphi* of Fab.) deposit their eggs in their nests, the larvæ proceeding from which devour the eggs of the legal occupants. The larvæ of a species of *Conops*, described by MM. Lachat and Audouin, live, like intestinal worms or the grubs of Strepsiptera, within the abdomen of the perfect bee; and after acquiring wings, they make their escape from between the segments.[2]

The species of the genus Bombus are extremely numerous, and seem extended over almost all the regions of the earth. "Scarcely any genus of the insect creation," observes Mr Kirby, "has so large a range as this of *Bombus*. It is found in the old world and in the new; and from the limits of phænogamous vegetation to the equator; but its metropolis appears to be within the temperate zone."[3] We cannot here enter into descriptive details. In Great Britain alone we have above forty different kinds. Of these, the *B. muscorum* (*Apis muscorum*, Linn.), called *Foggie* by the Scottish schoolboy, is recognisable by its reddish colour, uniform in the males, females, and neuters. In *B. lapidarius* the female is black, the abdomen with a red termination; the male (which is the *B. arbustorum* of Fab.) has the front of the head and both ends of the thorax yellow,—the abdomen having likewise a red extremity. This species differs from the others in its habit of forming its nest under stones. Hence its Latin trivial name. The *B. terrestris* is a very common and very beautiful species, widely distributed. It is black, with the posterior extremity of the thorax and the base of the abdomen yellow. The termination of the latter part is white. The *B. arcticus* of Kirby is black, with the base and apex of the thorax, and the anterior half of the abdomen, pale yellow. This insect is the *Apis alpina* of Otho Fabricius;[4] but not the species so called by Linnæus, which the former author supposed it to be. "The insect before us," says Mr Kirby, "differs so slightly from the description which O. Fabricius has given of that which he mistook for the *Apis alpina* of Linné, that there can be little or no doubt of their identity. He confesses that his specimens (and this bee appears to have abounded in West Greenland, as it was also observed to do in Melville Island, and wherever the expedition landed within the arctic circle) did not in all things agree with the characters assigned to that species. But he states, that as Linné had seen only a single specimen, he did not think himself at liberty to make a new species on account of an insignificant difference. Although, however, Linné had seen this bee only once, it has since been more frequently taken; and having received specimens of it from Sweden, through the kindness of Major Gyllenhal, which agree with the Linnæan description in every point but size (a circumstance easily explained, by supposing the original specimen a queen and those sent to me neuters), I can venture to assert that the two insects are perfectly distinct. *Bombus alpinus* is entirely black, with the upper side of the abdomen, all but the base, covered with orange-coloured or ferruginous hairs. The antennæ also of the female or neuter (an important distinction in a genus the species of which are usually only distinguished by the colour of their hirsuties) are proportionally shorter; and the short hairs that cover the tarsi are black."[5] The range of the true *B. arcticus* seems limited by the arctic circle, and extends from Greenland only in a westerly direction,—at least the species does not appear to have been observed in Lapland, Iceland,[6] or other eastern portions of that chilly zone. A European species, named *B. Lapponicus*, is said to be well known in North America, and to extend as far north as Nova Scotia.[7] Dr Richardson, the intrepid arctic traveller, informed the author of the present treatise, that in the course of the northern land expedition he saw some bees in very high latitudes, resembling our common humble-bee (*B. terrestris?*), but that he did not at the time ascertain the precise species; and the circumstances under which he was then placed unfortunately prevented his preserving specimens of the softer kinds of insects.[8]

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[1] *Mémoires du Mus. d'Hist. Nat.* t. viii. p. 147.

[2] *Journal de Physique*, Mars 1819.

[3] *Supplement to the App.* to Capt. Parry's *First Voyage*, p. 217.

[4] *Fauna Grœnlandica*, 155.

[5] *Supplement to the App.* to Capt. Parry's *First Voyage*, p. 217.

[6] Hooker's *Recollections of Iceland*, 1st edit. p. 34.

[7] *Dict. Class. d'Hist. Nat.* t. ii. p. 451.

[8] For a detailed history of the genus Bombus, the reader may consult, in addition to the works already named, "Observations on several species of the genus Apis, known by the name of Humble-Bees, and called Bombinatrices by Linnæus," by Mr P. Huber, in *Linn. Trans.* vol. vi. p. 214.

The remainder of our social Apiariæ are not characterized, like the preceding, by spines at the extremity of their posterior tibiæ. They form two genera.

In the genus **Apis**, Lat., or honey-bees *par excellence*, the workers have the first articulation of the posterior tarsi in the form of a lengthened square, and furnished on its interior face with a silky down, or divided into transverse or striated bands. We here place our invaluable garden species *Apis mellifica*, Linn. (of which we have represented the worker, the female, and the drone, on Plate CCXXXII. figs. 28, 30, and 31), on the wonderful history and attributes of which we could dilate with pleasure to ourselves, if not with satisfaction to our readers, had not the subject been already here treated of at length, and by an abler hand.[1] We shall merely here remark, that all the species of the genus Apis properly so called are peculiar to the ancient countries of the world, and that the domestic culture of the honey-bee is of an origin so remote as to be lost in the depth of ages. It served among the Egyptians as the hieroglyphical emblem of royalty, and has been more or less attended to by all civilized nations of whom we have any record; for innumerable in all but the darkest times are the writers who have told—

> Of treasure suck'd from buds and bells,
> For the pure keeping of those waxen cells,
> Where she, a statist prudent to confer
> Upon the public weal, a warrior bold,
> Radiant all over with unburnished gold,
> And armed with living spear for mortal fight,
> A cunning forager
> That spreads no waste,—a social builder, one
> In whom all busy offices unite,
> With all fine functions that afford delight,
> Safe through the winter storm in quiet dwells!

Our honey-bee (*A. mellifica*), though now well known in America, is in that country not an indigenous, but an imported species. Our land expeditions did not observe its occurrence to the north of Canada. The Americans have now *settled* the Missouri, as far as the 95th meridian; and it is probable that the New England men, in their journey westward, carried hives along with them. According to Mr Warden, the hive-bee was not found to the westward of the Mississippi prior to the year 1797; but it is now well known, and has been so for a considerable time, as high up the Missouri as the Maka nation,—having proceeded westward six hundred miles in fourteen years.[2] Such a distance seems great for these tiny creatures to advance by the ordinary process of swarming, even supposing that the flight of the new colonies was invariably in a western direction. It is at the rate of forty-three miles a year; but they have perhaps been smitten by the Yankee passion for settling beyond the clearings.[3]

Besides the species above named, various other honey-bees are found in different regions of the earth. The *Apis unicolor* of Lat. occurs in Madagascar and the Isle of France, and yields an esteemed honey of a green colour, like that of the Antilles. The *Apis Indica* of Fab. is found in Bengal and at Pondicherry. The *Apis fasciata* of Lat. is domesticated in Egypt, and is carried at certain seasons, for the sake of a double harvest, from Lower into Upper Egypt, just as we transport our own species, when the "flower-enamelled meads" are on the wane, to the blooming heather of the mountain solitudes. The *Apis Adansonii* is a species found in Senegal; and the *Apis Peronii* is native to the island of Timor, from whence it was first brought by the enterprising navigator whose name it bears. In relation to the European kinds, we have no other British species than the one so frequent in our garden-hives; but the Italians cultivate with success the *Apis Ligustica* of Spinola, which is by some entomologists supposed to occur in the wild state, and unimported, in the Morea and the Mediterranean Archipelago.[4]

The terminal genus of the social bees (and with it we conclude the hymenopterous order) is that called **Melipona** by Illiger and Latreille. It is distinguished from the preceding genus by the form of the first articulation of the posterior tarsi, which is narrower at the base, or in the shape of a reversed triangle, and without striæ on the silky brush of its interior face. The upper wings have only two complete cubital cells, while there are three in the genus Apis. These Hymenoptera inhabit South America, and build their nests, which resemble bagpipes, on the tops of trees, or in their cavities. Their honey is extremely sweet and agreeable, but very liquid, and apt to corrupt. The Indians form from it a favourite spirituous liquor. These details apply to *M. amalthea*, of which M. Cordier possesses a specimen enclosed in amber. The species in general have been observed by many travellers, but by few naturalists; and it is therefore not very easy to refer the recorded observations on their history to the proper species. Some nearly allied insects form the genus **Trigones** of Lat.[5]

ORDER VI.—LEPIDOPTERA, LINN.[6]

This splendid and much-admired order is characterized by the possession of four membranous and veined wings, covered by close-set scales, which frequently present the most brilliant and richly varied colours. The mouth consists of lengthened filaments or threads, the union of which forms an extensile spiral trunk or tongue, with which the nectareous juices of flowers are absorbed. Two palpi (corresponding to the labial palpi of masticating insects), consisting of three articulations, act as a sheath or guard on either side of the tongue when rolled up. The superior or maxillary palpi are usually very small, inconspicuous, or obsolete. The chrysalis is *obtected*, that is, covered over or

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[1] See the article Bee of this work, vol. iv. p. 518. We shall merely observe, in regard to the conversion of the neuter or working bee into a queen-mother, that a great degree of obscurity seems still to pervade the writings of all entomologists, whenever that singular subject is touched upon. Nothing in the history of these creatures has been more clearly demonstrated than the fact of such conversion,—but how a change of food should operate in the course of a few days a determinate change in the organic form and instinctive character of an insect, is as yet a mystery. We are more willing to believe than competent to understand several of M. Huber's facts. It is easy to conceive a greater development of particular organs, the germs of which previously existed,—but the positive alteration in the structure of the feet and maxillæ is not so readily accounted for. We still require some more precise and detailed information regarding this mysterious transmutation than the observations even of the Hubers have furnished. It would tend greatly to elucidate the subject if a series of comparisons could be made at different periods of their development, between the larvæ, nymphs, and perfect insects of the two kinds of queen-bees,—namely, those which were deposited originally in the royal cells (the legitimates), and those whose condition has been altered by the bees themselves in consequence of a failure in the royal line (the citizen-queens). It has not yet been ascertained at what periods or in what manner these singular changes of form take place, further than that the common maggot or bee-worm, on which the change is to be effected, must not exceed the age of three days.

[2] *Statistical, Political, and Historical Account of the United States of America*, vol. iii. p. 139.

[3] *Edinburgh Cabinet Library*, vol. ix. p. 387.

[4] In addition to the numerous works already cited, see a Monograph of the genus by Latreille, in the *Observations de Zool. et d'Anat. Comp. du Voyage de MM. Humboldt et Bonpland.*

[5] *Genera Crustac. et Insect.* t. iv. p. 182.

[6] Glossata, Fabricius.

Lepidoptera.

concealed by a crustaceous envelope, which however exhibits to a certain extent the external traces of the limbs, thorax, and abdomen.

The Lepidoptera are the most beautiful of all insects, and exhibit in their colouring every imaginable hue. It is not the mere brilliancy of the broader masses of colour, or their gorgeous combination, which alone delights our eyes, —but the exquisitely varied markings by which the hand of nature has traced her enigmatical characters on the "sail broad vans" of these fairy and fantastic creatures. What are the forms

> Painted on rich men's floors for one feast night,

or the most elaborate Mosaic pavement, when compared with the imbricated surface of a butterfly's wing![1] It was probably the highly ornamental nature of this order that induced Degeer and Olivier to place it at the head of the class of insects.

The mouth of the Lepidoptera does not differ essentially in its structure from the same organ in the masticating or mandibulated orders.[2] Savigny and Latreille have shown, in a manner at once precise and philosophical, that it is composed of the same pieces, and that these pieces are peculiarly appropriated to the functions which they are required to perform; thus some parts of little use exist in a merely rudimentary condition, while others of a more indispensable nature have gained an increase of development. The component parts are: a labrum, often nearly invisible, conical, or subulated; two corneous mandibles, very small, rudimentary, hairy, or garnished with small scales, and fixed, or apparently useless; two corneous maxillæ, in the form of tubular threads, generally much extended, and soldered together as far as the origin of the palpi, and forming by the union of their inner edges the trunk or sucker, of which the interior presents three canals; two maxillary palpi, often almost imperceptible, consisting of from one to three articulations, and inserted near the bend of the maxillæ; two labial or inferior palpi of three articulations, closely set with hairs or scales, and rising on each side of the trunk, of which they form a kind of sheath. The labium is composed of a single piece, flat, and triangular.

The antennæ vary in the different groups, but they are always composed of a great number of articulations. In the diurnal tribes they are simple, and generally terminated by a small inflation or knob; in the crepuscular they assume the form of an elongated or fusiform mass; in the nocturnal they are filiform or setaceous, whether pectinated or simple, and often plumose, especially in the males. In many species we find a pair of stemmatic eyes concealed among the scales, and placed between the ordinary eyes or organs of vision. The latter are hemispherical, of considerable size, and composed of innumerable facettes. The trunk is either ineffective or altogether wanting in some of the crepuscular and nocturnal tribes. The three segments of which the thorax of many other hexapod insects is visibly composed, seem here united into one,—the anterior being very short and transversal, as in the hymenopterous and dipterous orders. The form of the thorax is extremely uniform, and any apparent variety of aspect is caused chiefly by the extension of its hairy or scaly covering, which sometimes assumes the shape of a crest. The abdomen is composed of from six to seven segments. It is attached to the thorax by a very small portion of its diameter, and never offers either sting or ovipositor, although in a few females (as in *Cossus*) the terminal rings are narrow, and lengthened into the form of a pointed and retractile oviduct. The scales of the wings, on which their gorgeous beauty depends, are implanted by means of a small pedicle. Their figure is variable. They are usually somewhat elongated, rounded at the base from the side of the pedicle, and truncated at the outer extremity, which is generally toothed or serrated. The under wings frequently form on their inner margins a kind of canal for the reception of the abdomen. Among many of the diurnal kinds, the four wings, in a state of repose, are raised perpendicularly, so as to meet above the back; in the two other great sections they are horizontal or inclined; and in these there is often a strong spine or bristle on the anterior margin of the inferior wings, which being received by a buckle-like process of the under surface of the superior pair, maintains them in their position.

The legs of the Lepidoptera are as usual six in number, and the tarsi are composed of five articulations, and are terminated by a pair of hooks. In several diurnal genera the anterior pair are much shorter than the others, are useless as locomotive organs, and are folded on the sides of the chest; their tarsi being large, indistinctly articulated, and destitute of apparent hooks. The existence of the sense of smell in the class of insects is clearly demonstrated by the habits of many species of this order. The males of many nocturnal Lepidoptera discover the females of their own kind at a great distance, even when the latter are carefully and intentionally concealed from sight. The female is generally for the most part perceptibly, and in many instances considerably, larger than the males. They deposit their eggs, by an admirable and wisely granted instinct, not on the plants which they themselves affect during their first buoyant courses, but on such as are best adapted for the future nourishment of their crawling and wingless offspring.

The larvæ of Lepidoptera, usually known under the name of Caterpillars, are composed of twelve annular segments, exclusive of the head. They are furnished with nine stigmatic openings on each side, and the three anterior segments of the body are respectively furnished with a pair of short legs of a scaly consistence, terminated by a hook, and corresponding to the true legs of the perfect insect. There are, besides, from four to ten membranous or false feet upon the other segments. The body of caterpillars is generally elongated, soft, almost cylindrical, and frequently adorned by bright or beautiful colours, besides being variously provided with spines, hairs, or tubercles. Many are however naked, or unprotected by any other than a cutaneous covering. The head is harder than the other parts, and is covered by a corneous or scaly skin. It presents on each side six small shining grains, which are regarded as simple or stemmatic eyes; and two very short conical antennæ are likewise perceptible. The mouth is composed of two strong mandibles, a pair of maxillæ, a labium, and four palpi. The food of caterpillars consisting not of vegetable juices alone, but of the actual substance of the leaves and roots, and even of the well-matured woody fibres of timber trees, the masticating organs are beautifully adapted to their functions. But no sooner is the creeping and voracious larva about to transform itself into the "angelic butterfly," which floats on gaudy

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[1] We find the following memoranda among some notes illustrating the difference between the works of art and nature:

The Sussex pavement....................	contains	11	tessellæ or separate pieces in one inch square.
A modern mosaic picture..................		870	
The wing of a butterfly expanded......		100,736	
The same in the Aurelia state...........		931,808	

[2] See Plate CCXX. figs. 5 and 8, with the detailed description given in the note to page 68 of this volume.

pinions from flower to flower, and sustains itself only on the most ethereal of their nectareous juices, than the parts of the mouth undergo a change not less remarkable than that of the general form and aspect, and the long tubular proboscis above described is developed, in subservience to the habits of a new existence. The change, however, is by no means sudden or immediate, but is effected through the transitionary state of chrysalis, of which we have already said perhaps more than enough in our attempted exposition of the mysteries of transformation. We cannot, however, here avoid to notice the elaboration of that silky substance which, towards the termination of the caterpillar's career, becomes so singular a feature in its natural economy, and one of such vast importance in the artificial *habits* of the human race. It is formed in two long tortuous interior vessels, which, becoming gradually more slender at their upper extremities, terminate in a small conical spinner at the end of the labium. Had these insignificant secreting organs not existed in the silk-worm, or other allied species, what a difference of character would have been manifested in the lustrous aspect of baronial halls, and even of the courts of kings! It is curious, indeed, to consider how the breeding of a few millions of caterpillars should occasion such a disparity at different times in the circumstances of different tribes of the human race. When the wife and empress of Aurelian was refused a garment of silk, on account of its extreme costliness, the most ordinary classes of the Chinese were clad in that material from top to toe; and although among ourselves week-day and holiday are now alike profaned by uncouth forms, whose vast circumference is clothed "in silk attire," yet our own James the Sixth was forced to borrow a pair of silken hose from the Earl of Mar, that his state and bearing might be more effective in the presence of the ambassador of England,—"for ye would not, sure," said the royal pedant, "that your king should appear as a scrub before strangers."[1] King Henry the Eighth was the first of the English sovereigns who wore silk stockings.

Many caterpillars, in walking, fix the anterior feet on the plane of their position, and, bending their body upwards, they advance and fix their anal feet, assuming for a time the form of a loop. They then unfix their anterior hold, and stretching forward their bodies, proceed as it were by spanning the ground. They are hence called surveyors (*arpenteuses*) by the French naturalists. Others, known under the name of *Batons*, fix themselves, in repose, to twigs and branches by their hinder feet, and thus hold themselves out stiff and immoveable for many successive hours. It may easily be supposed that this extraordinary attitude must require the exercise of, comparatively speaking, most enormous strength. No vertebrated animal, not in a state of catalepsy, could sustain it even for a few seconds. We find accordingly (through the laborious investigations of a great interpreter of nature, Lyonnet) that even in the caterpillar of *Cossus ligniperda*, a species which lives in trees, but does not exercise itself in the way alluded to, there are above 4000 muscles. Many move along the ground rapidly by the successive motion of each segment, as if a wave were flowing over or pervading their bodies. The intestines of caterpillars consist of a large canal without inflections, the anterior portion being sometimes slightly separated in the form of a stomach, and the posterior forming a wrinkled cloaca. There are also four very long biliary vessels, usually inserted pretty far back.

The habits of caterpillars are very various in the different kinds. Although a great majority feed on vegetable substances, many of the smaller kinds are extremely destructive among stuffed birds, and all kinds of woollens. They will even devour leather, lard, wax, wafers, and all fatty matters. Many confine themselves to one particular substance, while others are polyphagous. Some unite in society, and form a silken tent to screen themselves from their natural enemies, and the extremes of heat and cold; others are independent and solitary. As they increase in size they cast their skins, and this process of sloughing generally takes place about four times. A great proportion, before assuming the chrysalis state, spin around them a web or cocoon, more or less compact according to their kind. In some (as in *Bombyx mori*, or the silk-worm) it is of a rich saffron colour, and of exquisite fineness; in others it is of a membranous texture, from being originally more compactly glutinous, instead of consisting of distinct threads. Many mingle with their funeral web or winding-sheet, particles of earth or decayed vegetable substances, which greatly increase the size of their cocoons. The chrysalids of the diurnal Lepidoptera are, however, naked or exposed, and are usually suspended by the posterior extremity, or fastened by a silken cord or girth around the middle of the body. They are also angular in their forms, while those of moths are rounded or cylindrical. In one or two of the crepuscular kinds, or Sphingides, the proboscis projects, and is encircled by a separate envelope, even in the chrysalis state. All the other parts are, however, swathed in a coriaceous covering, although the form of the wings and other members may be traced externally, in slight though distinct relief. The abdominal segments are capable of motion, like the "thews and sinews" of a warrior in plaited mail. The period of repose varies from a few weeks to one or two years. Such as assume the chrysalis state late in autumn, do not appear in the winged condition till the ensuing spring. Many remain in the egg state all winter; and such diurnal Lepidoptera as have two *flights* in the year are generally produced in the first place in spring from chrysalids which have lain torpid all winter, and become themselves the parents of another flight, which make their appearance at a later period of the same season. Thousands perish before attaining the perfect state, not only as the natural food of most passerine birds, but as the living bed of the Ichneumonides, which deposit their eggs in the fatty substance of the caterpillar, and thus by degrees deprive it of the source of life.

The observance of these and of other singularities, which we cannot here detail, will afford a never-failing source of interest to the student of nature's mysteries, and will assuredly yield an ampler and more enduring recompense than "Pyrrhos' maze or Epicurus' stye." In spite, however, of all that has been said and written of the wonders of entomology (and the subject, to be understood, must rather be seen than listened to, or even reflected on through the pages of the best instructed author), we fear that many continue to regard it with very inadequate notions. But how may not piety itself revolt at the thought of the most numerous works of an Almighty Creator's hand being regarded as trifling or unworthy of a deep and most reverential consideration. When Solomon, whose earthly glory never equalled the lustre of the "lilies of the field," desired us to ponder on a meet emblem of diligence and wisdom, it was not from what we consider as the most important parts of the creation that he drew his example:—"Go to the *ant*, thou sluggard; consider *her* ways, and be wise." So spake, and under a divine impulse, he who is himself emphatically called the "wisest of men." Yet in many a high-

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[1] *Edinburgh Cabinet Library*, viii. p. 154.

Lepidoptera Diurna.

flown moral and (pseudo) religious declamation, folly and ignorance not seldom combine to illustrate whatever is mean, insignificant, or worthless, by a reference to some unfortunate form of insect life. Even the pious Newton (not Sir Isaac, but the author of *Cardiphonia*, whose name was John) somewhere likens the extremest act of thoughtlessness and folly to a person breaking off from some worldly and important presence to "pursue a butterfly." Did the excellent author forget, or never know, that a butterfly is not only in itself a creature of such exquisite beauty that neither the "sea of light," nor any other of the most famous gems which ever from the brow of an eastern tyrant dazzled the dark eye of a trembling slave, can compare with it in varied and gorgeous lustre;—or did he expunge from his recollection that the same divine hand which formed man after his own likeness, also created every other thing which breathes the breath of life, and that all were declared *good* when seen by that eye, before whose brightness even the angels veil their faces? Compared with the eternal interests of man, we admit that all earthly pursuits, including even the best and purest—those of science—are as dust in the balance; but, bearing in mind our higher destiny, and yet believing that as there are celestial bodies and bodies terrestrial, so we cannot be better occupied than in devoting a convenient season to study (without which we cannot understand) the works of God,—for "the glory of the celestial is one, and the glory of the terrestrial is another," and both, though differing from each other in brightness, co-exist in divinest harmony, simply because

> The hand that made them is itself divine.

Therefore, though ourselves among the most loyal of liege subjects, we should not hesitate to pursue a butterfly, if wanting to our collection, "even in the presence of a crowned king." But this, we fear, is a digression.

In lepidopterous insects in the perfect state, we find a first lateral stomach or crop,—a second, inflated or turgid,—a small intestine, tolerably long,—and a cæcum near the cloaca.

The order is naturally divisible into three families, viz. Diurna, Crepuscularia, and Nocturna.

FAMILY I.—DIURNA.

The insects of this family, commonly called Butterflies, are never seen on the wing except during the day, and in a state of repose usually hold their wings erect. Their antennæ are capitated, or terminated by a club or knob, with a few exceptions, such as the splendid genus *Morpho*, in which they are almost filiform, and the Fabrician genus *Urania*, in which they become more slender towards their extremities. The caterpillars have always sixteen feet, and the chrysalids are naked and angular. These are the only lepidopterous insects in which we never find the exterior margin of the inferior wings presenting a rigid seta or bristle, for the retention of the superior pair.

The genus Papilio of Linnæus, divided into certain sections, contained the whole of that splendid and infinitely-varied tribe which we call Butterflies, of which the species are so numerous and diversified that naturalists soon felt the necessity of multiplying the genera, both because it was right so to do, and for the mere convenience of restricting the amount of species contained in each. In the later editions of the *Systema Naturæ*, Butterflies, or diurnal Lepidoptera, were divided into six phalanges. The first, called *Equites* (which now correspond to the true genus *Papilio*, as restricted by Latreille), was divided into *Troes* and *Achivi*, a division since ascertained to be rather unfortunate in some respects, in as far as it occasionally separates the males and females of the same species; the second was named *Heliconii;* the third *Parnassii;* the fourth *Danai*, subdivided into *Candidi* and *Festivi;* the fifth *Nymphales*, also subdivided into *Gemmati* and *Phalerati;* the sixth *Plebeii*, again divided into *Rurales* and *Urbicolæ*. Geoffroy (in his *Histoire abregée des Insectes*) follows the Linnæan system, and improves it chiefly by applying the principles previously established by Réaumur in his *Mémoires*. Degeer and Olivier likewise so far follow Linnæus as to retain the name *Papilio* as a generic term; but, in order to facilitate the labours of the student, they have introduced additional sections and subdivisions. The labours of Scopoli, as we have elsewhere observed,[1] are defective in relation to these insects, in consequence of his generic characters being drawn from the presence or absence of spots on the wings, and other distinctions which are of little or no value, except for the formation of artificial sections, or the discrimination of species. In the earlier works of Fabricius, scarcely any alterations were made in the arrangement of the Linnæan *Papiliones*. But in the *Entomologia Systematica* of that author, and still more in his *Systema Glossata* (left unfinished at the period of his death, a great number of genera were eventually created.[2] Latreille, in his numerous works, has constituted various generic groups, which appear to have been very generally adopted. Of the chief of these we shall speedily give account. Denis and Schiffermuller (in the *Catalogue des Lepidoptères de Vienne*) had previously benefited this branch of Entomology, by assuming the form and metamorphosis of the caterpillar as principal bases of their divisions; and Ochsenheimer has since successfully applied the same method to all the European species. Our ignorance of the history of the greater proportion of exotic groups has unfortunately retarded the more general application of the principles of an improved system, although Dr Horsfield's admirable *Lepidoptera Javanica* has done much to complete our knowledge of many fine Javanese species. Dumeril and Lamarck have also, each after his own manner, endeavoured to amend the classification of diurnal Lepidoptera; and in regard to pictorial works in this department, Clerk, Cramer, Engramelle, Hubner, Ernst, Esper, Stoll, Herbst, Jablonsky, Godart, and others, have published collections of coloured figures, some of which stand unrivalled in extent and magnificence by the most costly productions of those who have most successfully endeavoured to illustrate any of the kindred branches of natural science. Even in our own country, where natural history is so sparingly patronised, and so lightly valued, this beautiful branch of zoology has been rather sumptuously exhibited, and the names of Drury, Abbot, Wilkes, Shaw, Donovan, Lewin, Leach, Swainson, Stephens, Curtis, and Horsfield, will readily occur to the grateful recollection of the reader.

Indeed, on account of the exquisite beauty of their forms and colours, Butterflies have, from the earliest periods of natural history, greatly excited the zeal and admiration of collectors. They occur in all quarters of the world,—from the frozen shores of Greenland and Spitzbergen, to high southern latitudes; but the tropical regions of Asia and America are the most productive of large and splendidly-coloured species.

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[1] *Illustrations of Zoology*, letter-press preceding plate xxviii.

[2] Illiger has given an extract from the last-named work, in his *Magazin;* and the English reader will find it exhibited by J. G. Children, Esq. in the *Phil. Mag. and Annals* for February 1830.

M. Latreille divides the Linnæan Papiliones into two sections.

SECTION 1ST,

Contains all those butterflies which have but a single pair of spurs or spines to their tibiæ, and placed at the posterior extremity of these parts. When in a state of repose they raise their wings perpendicularly, joining them at the tips. Their antennæ are usually clubbed or inflated at the extremity, sometimes almost filiform. In this section are included the genus Papilio and the Hesperiæ *ruricolæ* of Fabricius. It is itself divisible as follows.

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Third joint of the inferior palpi sometimes almost wanting, sometimes very distinct, but equally well clothed with scales as that which precedes it. Hooks of the tarsi apparent or projecting.

Some of the genera of this subdivision are hexapod or six-footed, that is, all the feet are formed for walking, and are almost identical in both sexes. Their chrysalids, in addition to the common attachment by the posterior extremity, are fixed by the passing of a silken thread across the body. A few are enclosed in a rude cocoon. The central cell of the lower wing is closed inferiorly.

In PAPILIO (proper) of Latreille (Plate CCXXXIII. fig. 2), the inferior palpi are extremely short, scarcely reaching the clypeus with their upper extremity; their third joint is indistinct. The species of this genus are remarkable both for elegance of shape and beauty of colouring. Those spotted with red on the breast form the division of *Eguites Troes* of Linn.; those destitute of such marks he styled *Achivi* or Greeks. They abound in the tropical countries of both hemispheres, but are rare in more northern countries. Indeed we are not aware that more than three exist in Europe, viz. *P. Machaon*, *Podalirius*, and *Alexanor*, of which the first is a well-known native of some of the southern counties of England. The caterpillars of this genus are naked, and when alarmed protrude from the superior part of the neck a soft forked horn, that usually diffuses a penetrating and unpleasant odour. The chrysalis is exposed, and is supported by means of a silken band. In the genus PARNASSIUS of Lat. (*Doritis*, Fab.), Plate CCXXXIII. fig. 3, the inferior palpi evidently extend above the clypeus, taper to a point, and are distinctly triarticulated. The terminal button of the antennæ is short, almost ovoid and straight. The females are provided with a kind of corneous boat-shaped sack at the posterior extremity of the abdomen. The species of this interesting genus seem peculiar to the alpine or subalpine countries of Europe and the north of Asia. Their caterpillars possess a retractile tentaculum, like those of the preceding genus; but they form, prior to their transformation, a cocoon of leaves united by filaments of silk. The species which we have figured in the present work is a noted Swiss insect, *P. Apollo*. It inhabits alpine valleys. It is said, however, to occur on plains near Upsal, and other northern countries. In the genus THAIS of Fab. (Plate CCXXXIII. fig. 5), the palpi resemble those of the preceding, but the terminal button of the antennæ is elongated and curved, and there is no corneous pouch at the extremity of the abdomen of the female. The species are characteristic of the south of Europe. A few occur on mountains. In the preceding genera the internal margin of the under wings is concave or folded. In the two following the inferior wings project beneath the abdomen, and form a canal for its reception. The caterpillars, many of which feed on the Cruciferæ, have no tentaculum. The species correspond to the *Danai candidi* of Linn. and include all our common white Butterflies. In PIERIS, Lat. (*Pontia* of Fabricius and of the English entomologists), Plate CCXXXIII. fig. 6, the inferior palpi are almost cylindrical and slightly compressed, with the last articulation at least almost as long as the preceding. The club of the antennæ is ovoid. We have nine or ten British species, including what are usually called cabbage-butterflies, such as *P. brassicæ*, *napi*, &c.; also the more richly attired Orange Tip, or Lady of the Woods, *P. cardamines*.[1] Mr Stephens confines the generic title of *Pieris* to the hawthorn butterfly, *P. cratægi*, a species as yet unknown in Scotland. In the genus COLIAS of Fab. (Plate CCXXXIII. fig. 4), the club of the antennæ forms an elongated and reversed cone, and the inferior palpi are greatly compressed, with the last joint much shorter than that which precedes it. The indigenous species are in general more warmly coloured than those of the preceding genus.

Lepidoptera Diurna.

Other genera of this subdivision (*Tetrapoda*) have the anterior pair of feet much shorter than the others, folded on the breast, and unfit for walking; sometimes in both sexes, sometimes only in the males. The chrysalis is simply attached by its posterior extremity, and hangs with its head downwards. The genus DANAIS (*Euplœa*, Fab.), part of the *Danai festivi* of Linn. (Plate CCXXXIII. fig. 4), are distinguished by their triangular wings, and antennæ terminated by a kind of elongated and curved button. In IDEA, Fab. the wings are almost oval and elongated, and the antennæ nearly filiform. In HELICONIUS, Lat. (*P. Heliconii*, Linn.) (Plate CCXXXIII. fig. 7), the antennæ are twice the length of the head and thorax, and increase insensibly towards the extremity. In ACRÆA, Fab. the antennæ are shorter, and terminate in a more abrupt button. Those in which the inferior palpi are but slightly compressed, distant throughout their length, or at least at their extremity, and terminated abruptly by a slender and acicular joint, and in which the under surface of the wings is frequently ornamented by silvery spots, or by yellow ones upon a fulvous ground, form the genera CETOSIA and ARGYNNIS (Plate CCXXXIV. fig. 2) of Fabricius and Latreille. The caterpillars (ibid. fig. 3) are beset with spines or tubercles. In the former, of which several species have the wings elevated and elongated, the inferior palpi are distant throughout their entire length, the hooks of the tarsi are simple, and the club of the antennæ oblong. In the latter the club is short and abrupt, the hooks of the tarsi are unidentated, and the inferior palpi are distant only at their extremity. The inferior wings are often rounded. These butterflies are remarkable for the silvery spots upon their under surface. They are called *Fritillaries* by the English collectors. There are four or five indigenous species. The caterpillars have a pair of spines upon the neck, longer than the rest. Such as fall under the genus *Melitæa* of Fab. have yellow spots on the under surface, and the general markings above are more disposed in squares, like a chess-board. In *M. Seleni* and *Euphrosyne*, however, the upper surface is very similar to that of the preceding species, and there is an appearance of pearly or silvery lustre on the under surface of the lower wings. Latreille, we think wisely, unites the whole under the genus ARGYNNIS.

In the five following genera the inferior palpi are contiguous in their whole length, terminate gradually in a point, and are much compressed. The genus VANESSA (Plate CCXXXIII. fig. 9, and CCXXXIV. fig. 1) differs from the others in the antennæ, which are terminated abruptly by a short turbinated or ovoid button. The caterpillars are densely spinous (Plate CCXXXIII. fig. 10). Here is placed the common tortoise-shell (known in Scotland as the

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[1] For the indigenous species, see *Naturalist's Magazine*, vol. ii. p. 224.

Devil's Butterfly), *V. urticæ*, and several other British species, such as the Camberwell Beauty, *V. Antiopa*, and the Peacock Eye, *V. Io* (ibid. fig. 9). The Painted Lady, *V. cardui*, remarkable for the vast extent of its geographical distribution, being fully more widely dispersed than any other form of animal life with which we are acquainted, belongs to our present genus. It is, however, placed in the genus CYNTHIA by Mr Stephens. In the four following genera the antennæ terminate in an elongated club, or are almost filiform. In LIBYTHIA of Fab. the males alone have the anterior pair of feet extremely short, and tippet-like. The inferior palpi project observably in the manner of a beak. The upper wings are very angular. In BIBLIS, Fab. the palpi are also longer than the head, but more obtuse, and curved a little at their extremity. The anterior legs are abbreviated in both sexes, and the antennæ terminate in a much smaller club. The nerves of the superior wings seem strongly inflated at their origin. In NYMPHALIS, Lat. (Plate CCXXXIV. figs. 5, 7, 9), the legs resemble those of the preceding, but the inferior palpi are shorter. The club of the antennæ is more elongated than in Vanessa, from which they are not strongly distinguished. Their caterpillars are, however, different (ibid. fig. 4), being less spiny, and more elongated towards the posterior extremity, which is slightly forked. The species of this genus (of which, as a British example, we may name the Purple Emperor, placed in the genus APATURA by Mr Stephens) are frequently ornamented by brilliant and varied colours, and, when in prime condition, are highly prized by collectors. They are distinguished by the strength and thickness of their wings, which enable them to exercise a smooth, powerful, and sustained flight. Their motions are consequently not of that zigzag nature observable in many species, but steady and continuous, like the soaring of a bird of prey. They frequently haunt the summits of forest trees, and other elevated stations, and are therefore difficult to capture. This disadvantage, however, is to a certain extent obviated by the boldness of their disposition; for, when their situation is accessible, they are not deterred by an unsuccessful attack from settling again on the spot where they were first observed. The European species, such as the Purple Emperor above named (*N. Iris*), are taken by means of bag-nets, fixed to poles thirty feet high. They are said to be attracted by the odour of acrid or fermenting substances, and such are sometimes used by entomologists to induce them to descend from their inaccessible positions. The genus is very extensive. M. Godart[1] describes 267 different kinds. *Nymphalis Jasius*, the species which we have selected for illustration on the plate last referred to (figs. 7 and 9), is one of the most beautiful of European insects. We received it from M. Case-Nuove of Lyons. The genus MORPHO, Fab. (Plate CCXXXIV. fig. 8), differs from Nymphalis in its almost filiform antennæ, which are feebly and insensibly enlarged towards the extremities, but not clubbed. All the species are peculiar to South America, and are well deserving the special attention of those who desire to form a just notion of the splendour and magnificence of many lepidopterous insects. We could describe them with great pleasure did our limits admit of such details. M. Godart has separated, under the name of PAVONIA (ibid. fig. 10), certain species, of which the central cell of the lower wings is closed, and the most internal nerve of the upper pair is curved in the form of the letter S, in place of being straight or slightly arched. A species found in the East Indies, of which the lower wings are prolonged into a tail (*P. Phidippus*), forms the type of the genus AMATHUSIA of Fabricius. We have figured the larva and chrysalis on Plate CCXXXV. figs. 1 and 8. All the rest belong to the new world. Those which follow have also the discoidal cell of the lower wings closed posteriorly. Such are BRASSOLIS, Fab. (ibid. fig. 3), EUMENIA, Godart (do. fig. 5), EURYBIA, Illiger (do. fig. 10), and SATYRUS, Lat. (do. fig. 6). The caterpillars of the last-named genus are naked, or nearly so, and the posterior extremity of their body is narrowed into a furcated point. The chrysalids are bifid anteriorly, and their back is tuberculated.

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> Inferior palpi with three distinct joints, of which the third is almost naked, or much less thickly covered with scales than the preceding ones. The hooks of the tarsi are very small, and scarcely if at all projecting. The discoidal cell of the posterior wings is open posteriorly.

The caterpillars of this subdivision are oval, or resemble *Onisci* in their forms. The chrysalids are short, contracted, smooth, and always fixed, like the genus PAPILIO properly so called, by a silken thread across their bodies. These butterflies were classed by Linnæus among his *Plebei*, in the division of *Ruricolæ*, and Fabricius placed them in a corresponding section of his *Hesperiæ*. They form the genus ARGUS of M. Lamarck, and contain, among other species, all our beautiful little *Blues*, which in bright summer days so enliven our grassy downs, and almost all other spots of open sunshine.

Sometimes the antennæ terminate, as usual, in a small and solid button-like inflation. In the genus ERYCINA, Lat. (Plate CCXXXV. figs. 2 and 4), the anterior pair of feet are much shorter than the others, at least in the males. They belong to America. In the rest all the legs are alike in both sexes. In MYRINA of Fab. (ibid. fig. 11) the inferior palpi are long and projecting. In POLYOMMATUS (ibid. fig. 12) the palpi do not extend much beyond the epistoma. These beautiful little insects receive their name from the number of small eye-like spots with which their under surface is ornamented. We have a considerable amount of indigenous species, most of which are blue above, the females of some being brown. In the Scotch Argus (*P. Artaxerxes*), so common near Edinburgh in June and July, at the base of Arthur's Seat, above the line of the Railway, both sexes are blackish-brown above, with a variable white spot on the disk of the upper wings, and some lunated red spots, more or less distinct, on the under. The splendid little butterflies called *Coppers* are placed by our collectors in the genus LYCÆNA of Fabricius.

A few Lepidoptera of our present subdivision are remarkable for the peculiar form of their antennæ. Those of one of the sexes of the genus BARBICORNIS, Godart, are setaceous and plumy,—those of ZEPHYRIUS, Dalman (Plate CXXXXV. fig. 7), are terminated by ten or twelve globular joints, separated like the beads of a rosary.

SECTION 2D.

The second section of diurnal Lepidoptera contains those species of which the posterior tibiæ are furnished with two pair of spines, viz. a pair at their extremity, and another above. The lower wings are usually retained in a horizontal position, even when the insect is at rest, and the extremity of the antennæ very often forms a distinctly hooked point. Their caterpillars, judging from the few with which we are acquainted, bend together the leaves of plants for a protecting covering, and spin within that leafy chamber an extremely thin cocoon of silk, in which they are transformed into chrysalids. The latter are smooth, and without angular elevations. These Lepidoptera form the *Plebei Urbicolæ* of Linnæus, with the addition, by Latreille, of those rare and splendid insects placed by Fabricius in the genus Urania.

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[1] *Encyclopédie Méthodique*, art. *Papillon*.

The former belong to the genus Hesperia of Fab. (Plate CCXXXV. fig. 13), and are characterized by the distinctly clavate termination of the antennæ, and by the inferior palpi being short, broad, and thickly covered anteriorly with scales. Here are placed *H. alveolus*, *malvæ*, and *tages* (for chrysalis and larva see fig. 15), among the British species. In the genus Urania of Fab. just alluded to (ibid. figs. 9 and 14), the antennæ, at first filiform, become attenuated or setaceous at the extremity, and the inferior palpi are slender and elongated, with the second article greatly compressed, and the last much more attenuated, almost cylindrical, and naked. "The butterflies," says Mr Swainson, "comprising this remarkable genus, are perhaps the most splendid insects in creation. No art can effectually represent the changeable and resplendent green which relieves the velvet black of the wings, and which varies with every change of light. The typical species are found in Tropical America, where they fly with amazing rapidity, and perform, like their prototypes the swallows, annual migrations. When at rest, the anterior wings are flat or horizontal, but only slightly spread."[1] *U. Leilus* is found in Surinam, and is figured in Madame Merian's work on the insects of that country. *U. Ripheus* of Cramer (*Leilus Orientalis*, Swainson) was originally figured from a specimen taken at Chandernagor, in Bengal, and belonged to the rich cabinet of M. Gigot d'Orcy. We perceive, however, the following notice of its locality in a recent work: "Cette espèce, que l'on peut considerer comme le plus beau Lépidoptère connu, habite *Madagascar*. Elle a été prise une seule fois à Bourbon, où la chenille avoit peut-etre transportée accidentellement."[2] The synonymy of this exquisite insect has been greatly embroiled on account of Cramer supposing the species represented by his figure, which has six tails, to be identical with Drury's, which has none. Mr Swainson has shown that the latter insect, having clavated instead of filiform antennæ, is not only specifically distinct, but pertains to a different genus. He has named it *Rhipheus dasycephalus*.[3] In the *Nouv. Ann.* quoted below, the reader will find an account of the larva of *U. rhipheus*, which, in common with the caterpillars of the other species, has been hitherto unknown to naturalists. Mr Swainson has represented, with his usual elegance and accuracy, almost all the known species of these rare and beautiful insects. That which we have figured in illustration of our present article is a new species (*U. Boisduvalii*), lately published by M. Guerin.[4]

FAMILY II.—CREPUSCULARIA.

The most prominent species of this family are known by the name of Sphinxes or Hawk-moths. They are furnished with a spine or strong bristle on the anterior margin of the inferior wings, which being received by a process of the under surface of the superior pair, maintains them in a horizontal or somewhat inclined position in repose.[5] The character just mentioned is indeed perceptible also among the nocturnal tribes; but our present family is distinguished by the antennæ, which are prismatic or fusiform, usually thickest in the middle. These insects fly with great strength and celerity, owing to the extent and firm consistence of their wings, the powerful muscles by which they are moved, and the bird-like manner in which their taper bodies are poised. From their name, we would naturally infer that they are observed chiefly during the morning and evening twilight; but many species may be seen darting from flower to flower even at mid-day. As their capture is difficult, and their rearing from the caterpillar precarious, they are in general highly prized by collectors. In the larva state they have always sixteen feet. The chrysalis is cylindrical, blunt-headed, with a conical abdomen, and destitute of those points or angular prominences observable in so many of the diurnal Lepidoptera. They are usually enclosed in a cocoon, or concealed either in the earth or under some protecting body. They are supposed to derive the name of *Sphinx* from the peculiar attitude assumed by several of their caterpillars, which in some respects bear a resemblance to the fabled monster of antiquity. A few produce a humming sound. Latreille divides the family into four sections, which, in corresponding order, answer to the genera *Castnia* and *Sphinx* of Fabricius, and to those which he at first named *Sesia* and *Zygæna*.

The first section, named Hesperi-Sphinges, is composed of those species which connect the Hesperides of the preceding family with the Sphinges properly so called. The antennæ are always simple, thickened towards the middle, or at the extremity, which forms a hook, narrowed to a point, without any tuft of scales, at the end. They are all furnished with a distinct proboscis, and the inferior palpi are composed of three very apparent joints.

In the genus Agarista, Leach (Plate CCXXXVI. fig. 1), the inferior palpi are elongated, with the second joint strongly compressed, and the last slender and almost naked; the antennæ are simple, gradually thickened towards the middle, and then becoming attenuated, terminate in an elongated hook. In the genus Coronis, Lat. (ibid. fig. 2), the club of the antennæ is more developed. In the genus Castnia of Fabricius (ibid. fig. 3), all of which are from the new world, the antennæ resemble those of Agarista; but the palpi are shorter, broad, and cylindrical.

The second section, named Sphingides, have the antennæ always terminated by a little flake of scales; the inferior palpi are broad, or transversely compressed, thickly clothed with scales, and the third article generally indistinct. Most of the caterpillars have a smooth body, elongated, thickest towards the posterior extremity, which is furnished with a horn, the sides obliquely or longitudinally striped. They feed on leaves, and undergo their metamorphoses under ground, without spinning a cocoon. Many seem, however, to form a little vaulted chamber, with agglutinated walls, which protects them from the circumjacent earth. Here are arranged many fine insects belonging to the genus Sphinx properly so called (Plate CCXXXVI. figs. 5 and 6), of which the antennæ, from about their centre, form a kind of prismatic mass, either simply ciliated, or transversely striated on one side, in the manner of a rasp. The trunk is very distinct. These insects fly with great velocity, sometimes giving utterance to a humming noise, occasioned no doubt by the rapid vibration of their wings. Instead of settling upon flowers like bees and other insects, they are frequently observed merely to hover over or before them, and to extend their long tubular trunks towards the nectaries. This peculiar motion has probably obtained for them the appellation *hawk-moths*. *S. Atropos*, commonly called the death's-head moth, is one of the finest of the European species. When seized it sometimes utters a shrill cry, caused, according to Réaumur, by the friction of the palpi on the trunk,—in the opinion of M. Lorey, by the escape of air from two cavities in the abdomen. It makes its appearance in the perfect state during autumn. The caterpillar, at least in Britain, feeds voraciously on potato-leaves. It is difficult to rear beyond the chrysalis state. We had six specimens alive at one time during the summer of 1826, all of which entombed themselves after a time beneath the earth, but never made their appearance in the perfect state. On being examined after the lapse of ten or twelve months, they were found lying some inches below the surface, in the state of chrysalis, each in an egg-shaped hollow, formed by the caterpillar. They were quite light and stiff, and of course dead and unproductive of the desired *Imago*. The death's-head moth, in common with several others of the genus, is very widely distributed. We have received it from Africa and the East Indies; and M. Boisduval informs us that it is well known in the Isle of France. The natives of the latter country believe that the dust which it casts from its wings in flying through an apartment, is productive of blindness to the visual organs on which it falls. It is difficult to trace the origin of this fable, recorded by St Pierre in his Voyage to the Isle of France. We have many other native species, which we cannot here enumerate.[1] One of the rarest and most beautiful of the European species, *Sphinx Nerii* (genus *Deilephila*, Ochs.), occurs in Madagascar and the Mauritius. It likewise inhabits Asia Minor, Bengal, and the whole of Africa. We received it from the vicinity of Genoa. It has recently been captured in England.

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[1] *Zoological Illustrations*, second series, fol. 125.

[2] *Nouvelles Annales du Muséum d'Hist. Nat.* t. ii. p. 261.

[3] *Zoological Illustrations*, second series, plate 131.

[4] *Iconographie du Règne Animal*, pl. 82 (*Insectes*).

[5] This character, according to M. Godart, is wanting in some species of the genus *Smerinthus*.

Other genera of the Sphingides have the abdomen terminated by a broad tuft of scales. Such is our humming-bird hawk-moth, *Macroglossa Stellatarum*, Ochs. Some nearly allied species, to which Fabricius latterly applied the generic name of *Sesia* (such as *S. fusiformis*, *Bombyliformis*, &c.), are distinguished by the clear consistence of the greater portion of their wings. In the genus SMERINTHUS of Lat. (Plate CCXXXVI. fig. 11), the antennæ are toothed or serrated.

The third section, named SESIADES by Latreille, contains those species of which the antennæ are always simple, fusiform, and elongated, and frequently terminated, as in the preceding genera, by a little bundle of scales; the inferior palpi are narrow, slender, and distinctly triarticulate, the last tapering to a point. The posterior legs are furnished with very strong spurs. The abdomen is generally terminated by a kind of brush. The caterpillars live by gnawing the interior of the stalks and roots of plants, like those of the nocturnal kinds (such as *Hepialus* and *Cossus*); they are naked, have no posterior horn, and construct, with the debris of the substances on which they are nourished, a cocoon, in which they undergo their final metamorphoses.

In the genus Sesia of Latreille (*Ægeria*, Fab. Plate CCXXXVI. figs. 7, 12, and 13), the antennæ terminate in a little tuft of scales. The wings are horizontal, and composed of clearer vitreous portions, interrupted by darker coloured veins. The posterior extremity of the body is brush-like. Several species exhibit to a casual observer rather the appearance of wasps or flies, than of lepidopterous insects. The genus THYRIS of Hoffmansegg (ibid. fig. 8) resembles Sesia; but the antennæ are more slender, almost setaceous, and without any terminal tuft. The wings are angular and indented. The abdomen terminates in a point. In ÆGOCERA of Lat. (ibid. fig. 9), the antennæ also want the tuft, but they are evidently thickened towards the middle, and fusiform; the second joint of the inferior palpi is furnished with a bundle of hairs, which project in a beak-like fashion. The abdomen likewise terminates in a simple point. The wings are inclined, and entirely covered with scales.

The fourth and final section of our present family is that of the ZYGÆNIDES. It consists of Lepidoptera in which the antennæ, always terminated by a point destitute of a tuft, are sometimes simple in both sexes, fusiform, or resembling the horn of a ram, sometimes thickened towards the middle, almost setaceous, pectinated in both sexes, or at least in the males; the inferior palpi of medium size, or small, nearly cylindrical, and always formed of three distinct articulations. The wings, when at rest, are inclined; that is, sloped down laterally like the roof of a house, and present vitreous spots in many species. The abdomen is not brush-like at the extremity. The spurs of the posterior legs are usually small. The larvæ of these insects live exposed on various Leguminosæ, and other plants. They are short, inflated about the middle, and attenuated towards either end. Their bodies are smooth, or but slightly haired. In the course of their transformations they spin a pretty solid and coriaceous cocoon, attached to the stalk of a plant. The perfect insect issues from the chrysalis in a few weeks. The flight is somewhat heavy, and both sexes may frequently be taken together, reposing on the plants on which the female lays her eggs.

In the genus ZYGÆNA of Lat. (Plate CCXXXVI. figs. 4 and 10), which appears to be as yet unknown in the new world, the antennæ are simple in both sexes, and terminate abruptly in a fusiform mass, or one like a ram's horn. The inferior palpi rise above the clypeus, and are pointed at the end. This genus contains the Burnet moths of the English collectors, of which *L. loti* and *filipendulæ* are well-known examples. The genus SYNTOMIS of Illiger differs from Zygæna chiefly in the antennæ, which are not so thick, but slender, or insensibly fusiform. The inferior palpi are short and obtuse. In the genus ATYCHIA of Hoffm. (ibid. fig. 16), the antennæ are simple in the females, and bipectinated in the males. The inferior palpi are very hairy, and extend obviously beyond the clypeus. The wings are short. The spurs at the extremity of the posterior legs are strong. The genus PROCRIS of Lat. (ibid. fig. 17) approaches the preceding so far as respects the antennæ, but the inferior palpi are shorter and less hairy. An ornamental insect, the *Sphinx Statices* of Linn. affords a good example of this genus. It is called the green forester by Harris, and forms with another species the genus *Ino* of Leach and Stephens. Other Lepidoptera of this section have the antennæ in both sexes bipectinated, or furnished with a double row of elongated teeth. Such of them as have a distinct trunk form the genus GLAUCOPIS of Fab. (ibid. fig. 18)—those in which that organ is wanting or indistinct compose the genus AGLAOPE (ibid. fig. 15).

FAMILY III.—NOCTURNA.

The vast assemblage of species of which this great division is composed, are known under the familiar name of Moths, and correspond to the old and undivided genus *Phalæna* of Linnæus. Their wings, with a few exceptions, are *bridled*, in repose, by means of a bundle of setæ, or the corneous bristle before mentioned in our generalities of the preceding family. Their position is either horizontal or inclined; sometimes they embrace the sides and upper surface of the abdomen. The antennæ are setaceous, or become gradually narrower towards the extremity. They are frequently feathered or pectinated, especially in the males, and are usually more ample in that sex than in the females. The legs of the larvæ vary from ten to sixteen in number. In certain species both sexes seem to want the tongue; and the females of a few have no wings, or but the merest rudiments of those organs. The chrysalids are always rounded, or without angular points.

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[1] Mr Rennie's *Conspectus of the Butterflies and Moths found in Britain* will prove useful to those who cannot obtain access to the rarer or more costly works from which it is compiled.

These insects, as their family name imports, are seldom seen on the wing till after sunset. They continue their flight, throughout the mild and dewy nights of summer, till the morning twilight. During the brightness of the day season they conceal themselves in tangled vegetation, on the shady side of walls and buildings, on the under side of large leaves, or in the crevices of the gnarled bark of ancient forest-trees, and other sombre places. So astounded indeed are the greater number by the "garish eye of day," that when discovered by the sharp-sighted entomologist, they allow themselves to be taken prisoner without an effort to escape. A few, however, present exceptions to the general rule. Such, for example, are the males of *Bombyx zigzag*, which fly throughout the whole day, and fear not the brightest beams of "glorious Apollo." This same species presents a remarkable confirmation of what we have formerly stated, in the introductory portion of the present article, regarding the sense of smell in insects. The female of the moth just named is extremely sluggish, and seems seldom, if ever, to use her wings. When placed at an open window or elsewhere in an observable position, she will be speedily seen to receive the visits of the males, which fly swiftly towards her from all directions, undoubtedly guided by the sense of smell.

The classification of this family presents great difficulties to the entomologist in the way of a natural division into sections and sub-genera, and to it applies with peculiar force an observation made by Latreille regarding the entire order,—*Lepidopterorum ordo Entomologorum Scopulus.* In fact, the parts of the mouth, from the complex and greatly varied, yet clearly defined structure of which, in the masticating insects, so many excellent and available characters have been deduced, are among the lepidopterous tribes in general restricted in number, simple in form, and very similar in composition. The antennæ, too, especially among the nocturnal tribes, become rather sexual than generic distinctions;—and as the metamorphosis and general habits and history of many of the exotic species, which form the finest features in the richly stored cabinets of Europe, are almost entirely unknown, recourse cannot be had to such excellent and indeed indispensable aids towards a more natural and consistent classification. An accurate, perspicuous, and philosophical arrangement of the Lepidoptera, is therefore still a desideratum in our science.

Latreille, in his latest work (*Règne Animal*, second edition), divides the nocturnal Lepidoptera into *ten* sections. The species of which the wings are entire, or without fissures or digitations, compose the first nine. All those which, under the form of larva, live almost entirely exposed, or in fixed retreats, and of which many have less than sixteen feet, and which in their perfect state are characterized by very small or concealed upper palpi, more or less triangular wings, horizontal or decumbent, and not folding around the body, compose the first eight. The eighth itself is the only one of which the caterpillars have fourteen feet, of which two are anal. If in certain others the same number exists, the anal are wanting.

The first four sections correspond to the divisions *Attacus* and *Bombyx* of the genus Phalæna of Linnæus. The trunk is usually rudimentary or very small, and its two filaments are not united. The inferior palpi, with a few exceptions, are small and almost cylindrical. The antennæ, at least in the males, are pectinated or serrated. The wings are horizontal or decumbent, and in several the lower project, in a state of repose, beyond the upper pair. In some, also, the buckle-like process formerly mentioned as fixing the wings together, is here wanting. The thorax is smooth or uniform, as well as the abdomen, and woolly. The latter portion is for the greater part very voluminous in the females. The cocoon of the chrysalis is generally what may be called well *felted*, and of pretty solid consistence. Although the Nocturna of Latreille's fourth section (*Aposura*) bear a close relation to those which precede them, their caterpillars nevertheless offer a character unique and unexampled in the lepidopterous order,—the absence of the anal feet. We shall here give a brief sketch of the general characters of the nocturnal tribes, in accordance with the system of Latreille.

SECTION 1ST, HEPIALITES.

We may here name as types the genera *Hepialus* and *Cossus* of Fabricius. The caterpillars are rarely met with, as they conceal themselves in the interior of the plants on which they feed. The cocoons which they form are composed in great part of particles of those same plants. The edges of the abdominal rings or segments of the chrysalis are toothed or spinous. The antennæ of the perfect insect are always short, and most generally present only one kind of small, short, rounded, and close-set teeth. Those of some others terminate always in a simple thread, but are furnished inferiorly in the males with a double row of barbs. The trunk is always very short, and not very obvious. The wings are decumbent, and generally elongated. The last rings of the abdomen in the female form a kind of oviduct or tail. In the larva state these insects are very destructive to trees, edible plants, and other useful products of the vegetable kingdom.

Sometimes the antennæ, almost conformable in both sexes, have only very short teeth disposed in one or two rows. Such are the three following genera. In HEPIALUS of Fab. the antennæ are almost granular, and much shorter than the thorax. The under wings are usually destitute of the curb or spine. The caterpillars dwell in the earth, and gnaw the roots of plants (Plate CCXXXVI. fig. 27). A very abundant species, called the Ghost-moth, *H. humuli*, Fab., is characterized by the upper wings of the males being of a silvery white, without spots,—those of the female reddish yellow, with spots of a deeper hue. The larva is extremely destructive to hops, and also exists in great quantities in districts where that useful plant is unknown. It is often seen hovering over churchyards with a short pendulous motion to and fro, and is also frequently observed in pasture-fields, and plots of grass in garden grounds. In the genus COSSUS of Fab. (ibid. fig. 14), the antennæ are at least as long as the thorax, and present on their inner side a range of small lamellar teeth, short and rounded at the end. The caterpillars live in the interior of trees, and make use of the saw-dust produced by the action of their mandibles in the formation of their cocoons. The chrysalids advance by a peculiar and instinctive motion to the external apertures of their ligneous dwellings, just at the moment of their final development, when their wings are about to expand. We doubt not that the little spinous projections with which the sides of the abdomen are armed, aid them greatly in that progressive motion. A wriggling movement would naturally produce an advance upwards or forwards, but retreat would be impossible. The *Cossus ligniperda* is a noted example of the genus. In the larva state (ibid. fig. 19) it is extremely destructive to elm trees, which it perforates almost to the core, and by degrees produces first an unhealthy condition, rendered visible by a peculiar colour of the leaves, and finally decay and death. In the company of an honoured friend, the Rev. John Fleming of Rairigg, Windermere, we lately witnessed the hewing down of an old elm tree, which had braved the blasts of many stern winters, but had evidently become paralysed in its vital functions by the inroads of some insidious foe. By accident the large scaly head of a caterpillar was one day seen protruding from the rugged bark; and some other circumstances led to the belief that the tree was infested. To ascertain the cause of the disease with certainty, and to stay if possible its progress through the neighbouring groves, the sylvan monarch was consigned to the tender mercies of the woodmen of Bowness; and on being felled and hewn in different parts, we discovered several dozens of very large caterpillars of *Cossus ligniperda*, chiefly in the thickest part of the tree, a few feet above the ground, and several inches within the bark. They gave out, as we extracted them, a very peculiar odour, of an oily nature, and sufficiently repelling, we should suppose, to render it improbable that these larvæ were eaten by the ancients. It is however a well-received opinion, that the *Cossus* described by Pliny, and regarded by the Romans as a most delicious fare, was the caterpillar in question. It is frequently found in the willow as well as in the elm, and may possibly extend its ravages to the oak, the nidus assigned by Pliny to his edible worm. The latter, however, was most likely the larva of *Prionus coriarius*, or some other of the larger long-horned beetles; the more especially as we know from Madame Merian and other writers, that the grub of a congener, *Cerambyx damicornis*, is eaten in Surinam and the West Indies, both by slaves and freemen. The perfect insect of the *Cossus ligniperda* is of an ashy grey, with numerous small black lines on the upper wings. The posterior extremity of the thorax is yellowish, with a black line. We forgot to mention, that the oily odour of the caterpillar is by some considered to proceed from a reservoir of a peculiar fluid which the insect disgorges, for the purpose, it is believed, of softening the timber on which it feeds, and in which, as it increases in size, it perforates its hidden chambers. It is also remarkable as having afforded the subject of an extraordinary anatomical investigation by Lyonnet, detailed in his famous *Traité Anatomique de la Chenille du Saule.* The enthusiasm of a French writer has induced him, while lauding the merits of that signal publication, to allude to its subject-matter under the dignifying appellation of "the immortal worm!" The reader may satisfy his curiosity as to its external aspect, by inspecting the 19th figure of our 236th plate. On the same plate, fig. 14, we have represented the winged state of an American species, *C. Macmurtrei* of Boisduval. The genus STYGIA of Draparnaud (ibid. fig. 24), placed by some writers among the *Zygænides*, is ranked by Latreille where we now introduce it. The antennæ have a double row throughout their whole length, of small, short, straight teeth, dilated and rounded at the end.[1]

Sometimes (and this character distinguishes the following genus from those enumerated in the preceding paragraph) the antennæ differ greatly in the sexes; those of the males being furnished inferiorly with a double row of barbs, and terminated by a filament; those of the females being entirely simple, but cottony at the base. Such are the species of the genus ZEUZERA of Lat. (Plate CCXXXVI. fig. 20), of which *Z. æsculi* is a beautiful indigenous example. Its larva dwells in the interior of the sweet chesnut tree, and in that of pear and apple trees. The body of the perfect insect is of a beautiful white, with blue rings on the abdomen, and numerous little spots of the same colour on the upper wings. It is not a common species.

SECTION 2D, BOMBYCITES.

This section may be distinguished, both from that which precedes and that which follows it, by the following characters: The trunk is always very short, and merely rudimentary; the wings are either extended and horizontal, or decumbent, but the inferior wings extend laterally beyond the upper ones; the antennæ of the males are pectinated.

The caterpillars live exposed, and devour the more tender parts of vegetables. They usually spin a cocoon of pure silk. The chrysalids have no spiny processes or dentations on the edges of the rings of the abdomen.

The species with horizontal and extended wings (the Phalænæ Attaci of Linn.) form the genus SATURNIA of Schrank (Plate CCXXXVI. fig. 25), with which Latreille combines AGLIA (*Bombyx tau*) of Ochsenheimer. It comprehends many magnificent species, such as *S. atlas* of China, called *porte-miroir* by the French, on account of the transparent or vitreous portions of the wings. *S. luna*, of a fine and delicate green colour, is an American species, remarkable for the extended tail-like appendages of the under wings.[2] The cocoons of two other species of this division, *Bombyx mylitta* of Fab. and *Phalæna cynthia* of Drury, have been employed for their silk from time immemorial in Bengal. The first of these species appears to be identical with the *Ph. paphia* of Dr Roxburgh. It occurs in great abundance in Bengal, and in many parts of the adjoining country, and affords a plentiful supply of a very durable though coarse and dark-coloured silk called *Tusseh*, much used by the Brahmins and other sects of Hindoos. This species cannot be domesticated; but the hill people go into the jungles, and when they perceive the dung of the caterpillars under a tree, they immediately search for them among the branches, and carry off whatever they require. These they distribute on the asseen trees (*Terminalia alata glabrata* of Roxb.), and as long as they continue in the caterpillar state, the Pariahs guard them from birds by day and from bats by night. The natural food of this species is the *Byer* tree of the Hindoos, called *Rhamnus jujuba* by botanists. The Jaroo cocoons are produced from a mere variety, not a distinct species, of this insect. The Arrindy silk-worm, however, belongs to an entirely different species, the *Phalæna cynthia* above named. It appears peculiar to two districts in the interior of Bengal, viz. Rungpore and Dinagepore, where it is reared in a domestic state. The food of this caterpillar consists entirely of the leaves of the common *Ricinus*, or *Palma Christi*, which the natives call arrindy, and hence the name by which the insect is itself distinguished.[3] The cocoons are in general about two inches in length and three inches in circumference, pointed at either end; they are of a white or yellowish colour, and their texture is extremely soft and delicate. The filament indeed is so remarkably fine, that this silk cannot be wound off, but is spun like cotton. The yarn is wove into a kind of coarse white cloth, of a seemingly loose texture; but of such extreme durability that the life of one person is seldom sufficient to wear out a garment of it, so that the same piece frequently descends from parent to child. It must always be washed in cold water.[1]

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[1] M. de Villiers has published some new details regarding *S. Australis*, in the *Annales de la Soc. Linn. de Paris*, v. 473. The antennæ in our figure are, we fear, not quite accurately represented, though, from want of a specimen, we cannot correct them. Compare Godart, *Papil. de France*, iii. pl. 22, fig. 29; and Guerin, *Iconog.* (*Insectes*), pl. 85, fig. 4.

[2] This species has been bred at Altona by Mr Zincken von Sommer, from eggs imported from America. We have figured the larva on Plate CCXXXVI. fig. 23.

[3] *Edinburgh Cabinet Library*, British India, vol. iii. p. 155.

The principal European species of the genus Saturnia are known under the names of peacock and emperor moths, &c. such as *S. pavonia major* and *minor*. The former is the largest moth in Europe, and has been known to remain in the chrysalis state for three years.

Other Bombycites have the superior wings decumbent, with the exterior margin of the inferior pair projecting almost horizontally beyond them,—*alæ reversæ*. In the genus LASIOCAMPA (Plate CCXXXVI. fig. 26), the palpi project in the form of a rostrum, and the inferior wings are frequently dentated; some of the species bear a resemblance to little bundles of dried leaves; such are *L. quercifolia* and others. In the genus BOMBYX properly so called (ibid. fig. 21) the inferior palpi exhibit no remarkable projection. Here is placed the famous *Bombyx mori*, or true silk-worm moth, of a whitish colour, with two or three obscure and transverse streaks, and a lunate spot on the superior wings. The caterpillar feeds on the leaves of the mulberry, and spins an oval cocoon of a close tissue of the finest silk, usually of a yellow colour, but sometimes white. A variety is now preferred abroad, which always yields the latter colour. Although this sumptuous product is now "familiar as household words," its nature and origin were but obscurely, if at all, known in ancient times; and even in the days of Aurelian it was valued at its weight in gold. This was probably owing to the mode in which the material was procured by the merchants of Alexandria, who had no direct intercourse with China, the only country in which the silk-worm was at that time reared. According to Latreille, the city of Turfan, in Little Bucharia, was for a long time the rendezvous of the western caravans, and the chief entrepôt of the Chinese silks. It was the metropolis of the Seres of Upper Asia, or of the Serica of Ptolemy, placed, according to that author, between the Ganges and the Eastern Ocean. Hence the *Serica vestis* of the Romans, and the word *Sericum*, their name for silk. Driven from their country by the Huns, the Seres established themselves in Great Bucharia and in India. It was from one of their colonies, Ser-hend (*Ser-indi*), that certain Greek missionaries, in the reign of Justinian, carried the eggs of the silk-worm to Constantinople. Its cultivation spread, at the period of the first Crusades, from the Morea into Sicily, the kingdom of Naples, and, several centuries afterwards, under the administration of Sully more especially, into France, to which country it is now a source of great wealth. Silks were also anciently obtained by sea or land from the kingdoms of Pegu and Ava, or the Oriental Seres, most frequently mentioned in the writings of the earlier geographers.[2] Though the manufactures of silk were lauded in terms of the highest admiration both by Greek and Roman writers, they were in frequent use for some centuries before any certain knowledge appears to have been obtained, either of the precise countries from which the material was derived, or of the mode by which it was produced. By some it was supposed to be a fine down adhering to the leaves of trees or flowers, by others it was regarded as a delicate kind of wool or cotton;[3] and even those who had some idea of its insect origin were incorrectly informed of the natural mode of its formation. The court of the Greek emperors, which surpassed even those of the Asiatic sovereigns in splendour and magnificence, became profuse in its display of this costly luxury; but as the Persians, from the advantages which their local situation gave them over the merchants from the Arabian Gulf, were enabled to supplant them in all those marts of India to which silk was brought by sea from the East, and as they had it in their power to cut off the caravans which travelled by land from China through their own northern provinces, Constantinople thus became dependent on a rival power for an article which its sumptuous nobles deemed essential to the enjoyment of refined life. Of course the Persians, with the usual rapacity of monopolists, raised the price to an exorbitant height, and many attempts were made by Justinian to free his subjects from such exaction. An accidental circumstance is said to have accomplished what the wisdom of the great legislator was unable to achieve. Two Persian monks, who had been employed as missionaries in one of the Christian churches established in India, had penetrated into the country of the Seres, that is, to China, where they observed the natural operations of the silk-worm, and acquired a knowledge of the arts of man in working up its produce into so many rich and costly fabrics. The love of lucre, mingled perhaps with a feeling of indignation that so valuable a branch of commerce should be enjoyed by unbelieving nations, induced them to repair to Constantinople, where they explained to the emperor the true origin of silk, and the various modes by which it was prepared and manufactured. Encouraged by the most liberal promises, they undertook to transport a sufficient supply of these extraordinary worms to Constantinople, which they effected by conveying the eggs in the interior of a hollow cane. They were hatched, it is said, by the heat of a dunghill, and the larvæ were fed with the leaves of wild mulberry.[4] They grew and prospered, worked their webs, underwent their accustomed metamorphosis, and multiplied their kind according to use and wont; and thus, as already intimated, becoming extensively cultivated throughout all the southern countries of our continent, they effected an important change in the commercial relations which had so long existed between Europe and the East.[5]

Another curious species of the genus Bombyx is the processionnary moth, *B. processionnea*, Fab. The caterpillars of this insect live in society on oak trees, where, when young, they spin in common a silken tent, in which they dwell together in unity. They frequently change their domicil until after the third casting of their skins, on which they remain more stationary, forming a new habitation resembling a kind of sack, divided interiorly into several cells. They usually issue forth in the evening, in a very singular order of procession. A single individual takes the lead, and serves as guide, two others follow, forming the second line, then three abreast, next four, and so on for many ensuing columns, each regularly augmented by the addition of a single larva, and all following the course of their first adventurous leader. After a certain time each spins a cocoon alongside that of its neighbour, mingling the hairs of its body with the silken tissue. These hairs, Latreille remarks, are, in common with those of several other kinds, extremely small and fine; and sometimes working their way into the human skin, occasion violent itchings, accompanied by swelling. The inhabitants of Madagascar are known to employ for economical purposes the silk of a caterpillar which likewise dwells in great communities,—a commonwealth of worms. Their nest is sometimes three feet high, and so closely packed with cocoons (500 have been counted in a single mass) that not the smallest hiatus is to be found. The species, however, belongs to the genus *Sericaria* of the ensuing section.

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[1] *Account of the Tusseh and Arrindy Silk-Worms of Bengal*, by William Roxburgh, M.D. &c. *Linn. Trans.* vol. vii. p. 33.

[2] *Règne Animal*, t. v. p. 402.

[3] Robertson's *Historical Disquisition concerning Ancient India.*

[4] Procopius, *De Bello Gothico.*

[5] See Gibbon's *Decline and Fall*, &c. Reign of Justinian; also *Edinburgh Cabinet Library*, British India, vol. iii. p. 152–3.

SECTION 3D, PSEUDO-BOMBYCES.

These consist of Lepidoptera in which the inferior wings (in common with those of all the remaining nocturnal tribes) are provided with a curb, which attaches them to the superior when at rest. They are then entirely covered by the latter, and both are decumbent or horizontal, but with the inner edges overlapped (*en recouvrement*, Lat.). The trunk among the concluding members of the section begins to lengthen, and scarcely differs in the final genera from that of other Lepidoptera, except that it is somewhat shorter. The antennæ are entirely pectinated or serrated, at least in the males. The caterpillars live on the exterior parts of vegetation.

Latreille distinguishes first those species in which the trunk is very short, and apparently unadapted to the purposes of suction.

In some, and these are the greater number, the caterpillars live exposed or uncovered, and do not fabricate portable dwellings. Of these, some are elongated, furnished with ordinary feet, well adapted for walking; the rings of the body not soldered above. In the genera SERICARIA of Lat. (Plate CCXXXVI. fig. 22), and NOTODONTA of Ochs. (Plate CCXXXVII. fig. 1), both sexes have well-developed wings. In the former, which contains the *B. dispar* of Fab. so remarkable for the great size of the female, and the difference of her general aspect when compared with the male, the upper wings exhibit no dentations on their inner border. In the latter, which contains *Ph. zigzag* of Linn. that border is dentated. In the genus ORGYIA of Ochs. (ibid. fig. 2), the females are almost apterous (fig. 3), and the caterpillars (fig. 4) are beautifully adorned with aigrettes, or little plumes or tufts of hair. In others of the same tribe the caterpillars creep rather than walk, their feet being extremely short, and even the scaly ones retractile; the body is oval like that of an oniscus, with the skin soldered above from the second ring, so as to form a kind of arch, beneath which the head is withdrawn. These compose the genus LIMACODES, Lat. of which the caterpillars seem to represent, in this section of the Nocturna, those of certain diurnal Lepidootera, such as the genus *Polyommatus*.

Other genera of Pseudo-Bombyces are distinguished from the preceding by the possession of a very distinct trunk, which, when unrolled, extends far beyond the head. The disposition of their colours somewhat resembles that of those diurnal species called chess-boards (*damiers*) by the French. Many of them are extremely rich and beautiful in their adornment. In CHELONIA of Godart (*Arctia*, Schr.) Plate CCXXXVII. fig. 5, the wings are decumbent in repose, the antennæ pectinated in the males, the inferior palpi very hairy, and the trunk short. To this genus belongs that common but superb species commonly called the Tiger-moth (*B. caja*, Fab.). It is produced from the blackish-brown creeping caterpillar usually known in Scotland as " the hairy worm." In CALLIMORPHA, Lat. (ibid. fig. 6), the wings are also decumbent, but the antennæ are at most only ciliated in the males; the inferior palpi are merely covered by little scales, and the trunk is long. *C. Jacobœa* is an ornamental British species, known to our older writers under the names of Pink-underwing, and Cinnabar-moth. The upper wings are brown, with a streak and two spots of carmine. The under pair are carmine, with a blackish border. The caterpillar is hairy and black, and feeds on the flowers of the rag-wort. In LITHOSIA of Fab. the wings are laid as it were horizontally upon the body.

SECTION 4TH, APOSURA, Lat.

The insects of this division are characterized by a peculiarity already alluded to,—the want of feet on the anal segment of the body of the larvæ. They derive their name from that circumstance. The posterior extremity of the body terminates in a point, which in several is forked, or even exhibits two articulated appendages, long and flexile, and forming a kind of tail. The perfect insects differ but little from the preceding in regard to their trunk, palpi, and antennæ. Some, such as DICRANOURA of Godart (Plate CCXXXVII. fig. 7), have the external aspect of Sericaria and Chelonia, with the antennæ of the males terminating in a small simple curved thread. The posterior extremity of the larva is forked (ibid. fig. 8). Others, such as PLATYPTERIX, Lat. bear a great resemblance to the Phalænæ properly so called. Their wings are broad, and the superior angle of the posterior extremity of the anterior pair is somewhat prolonged or falcated. The body is slender. That of the caterpillar terminates in a simple truncated point. In that state they bend over the edges of the leaves of plants, and fix them down by silken cords, so as to form a protecting habitation, which at the same time they partly consume as their natural food. The cocoon of the chrysalis is very bare.

SECTION 5TH, NOCTUÆLITES, Lat.

The species of this extensive section are similar to the preceding insects in the figure and relative proportion of their wings, and their position in repose; but they present the two following distinguishing characters: A horny, spirally rolled, and generally elongated trunk; inferior palpi, terminated abruptly by a very small article, much more slender than that which precedes it,—the latter being broader and compressed. These genera have the body more covered by scales than by a woolly down. Their antennæ are usually simple. The thorax is frequently crested above, and the abdomen assumes the form of an elongated cone. Their flight is rapid, and some of the species make their appearance during the day. The caterpillars have usually sixteen feet. Some have only twelve or fourteen, but the posterior or anal pair are never wanting; and in those which present but twelve the anterior pair of the membranous ones are as long as the next ensuing. The greater proportion spin a cocoon, in which they undergo their metamorphosis. These Lepidoptera correspond to the division named *Noctuæ* of the genus *Phalæna* of Linn.

All the generic groups recently established, and of which the characters are derived rather from the caterpillar than the perfect insect, are referred by Latreille to the two genera which follow. In the genus EREBUS of Lat. (Plate CCXXXVII. figs. 10 and 14), the wings are always extended and horizontal, and the terminal joint of the palpi is elongated, elevated, cylindrical, or slightly compressed, and naked. With the exception of a single species, *Ophiusa scapulosa* of Ochsenheimer, which occurs in Spain, all these insects are of exotic origin. We have figured a superb example, " the glory of the Noctuidæ," as it is well named by Mr Kirby, on the fourth plate of the first volume of our *Illustrations of Zoology*. It is the *Erebus strix* of Latreille, and is known also under the title of the

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great owl moth of Brazil. It measures nearly a foot in breadth from tip to tip of the extended upper wings. In the genus Noctua of Fab. and Lat. (ibid. fig. 9) the terminal joint of the inferior palpi is short, and covered with scales, like that which precedes it.[1] Of those with six feet, which are the greater number, we may mention as a British species *N. sponsa*, Fab. The caterpillar lives upon the oak, is of a greyish colour, and obscurely and irregularly spotted. It is marked with small tubercles, and the eighth ring bears a projection, on which there is a yellow plate. This larva, and some other nearly allied kinds, are called *lichenées* by the French naturalists, on account of their resemblance to, and the difficulty with which they are sometimes distinguished from, various kinds of bark-supported lichens.[2] The anterior four of the membranous feet are shorter than the others, and they walk like the *surveyors*. Many other well-known species are arranged with that just mentioned. The caterpillars of certain others have only twelve feet, and the perfect insects are frequently ornamented with golden or silvery spots upon the upper wings. Such are two well-known British species, *N. gamma* and *chrysitis*. The former of these receives its name from a character resembling the Greek letter γ inscribed in gold upon its upper wings. "This creature," say Messrs Kirby and Spence, speaking of the larva, "affords a pregnant instance of the power of Providence to let loose an animal to the work of destruction and punishment. Though common with us, it is seldom the cause of more than trivial injury; but in the year 1735 it was so incredibly multiplied in France as to infest the whole country. On the great roads, wherever you cast your eyes, you might see vast numbers traversing them in all directions to pass from field to field; but their ravages were particularly felt in the kitchen gardens, where they devoured every thing, whether pulse or pot-herbs, so that nothing was left besides the stalks and veins of the leaves. The credulous multitude thought they were poisonous, report affirming that in some instances the eating of them had been followed by fatal effects. In consequence of this alarming idea, herbs were banished for several weeks from the soups of Paris. Fortunately these destroyers did not meddle with the corn, or famine would have followed in their train. Réaumur has proved that a single pair of these insects might in one season produce 80,000; so that, were the friendly Ichneumons removed, to which the mercy of Heaven has given it in charge to keep their numbers within due limits, we should no longer enjoy the comfort of vegetables with our animal food, and probably soon become the prey of scorbutic diseases."[3] The caterpillars of some other species have the habit of eating the petals of the flowers of the plants on which they dwell. The antennæ of certain kinds are pectinated, such as *N. graminis*, an insect which has sometimes proved extremely destructive to the meadows in Sweden. We may conclude by observing that caterpillars believed to belong to this genus have been seen to exercise a curious, and, as we would suppose it, an unnatural instinct,—they seize upon other larvæ, even of their own species, transfix them by the middle, and sucking out their interior juices, leave them nothing but their own skins. When we mention that Olivier (in *Encyclopédie Méthodique*) describes 459 species of the Fabrician genus Noctua, the reader will readily admit that many of the new generic groups, to which we have been unable to do more than allude, are extremely desirable, were it for nothing else than mere convenience, independent of any higher reasons resulting from the nature of things.

Section 6th, Tortrices, Linn.

These are very nearly allied to the Lepidoptera of the two preceding sections. The upper wings, of which the posterior margin is arcuated at the base and then restricted, and their short and broad contour, forming a truncated oval, bestows a peculiar physiognomy upon the species in question. They are named by the French *Phalènes à larges epaules*, *Phalènes chappes*, &c. They are all provided with a distinct trunk, and the inferior palpi are generally very like those of Noctua, but somewhat projecting. They are of smallish size, agreeably coloured, with the wings decumbent, but flattish, or almost horizontal, and covering the body,—the inner margins of the upper pair even overlapping each other a little in a state of repose. The caterpillars have sixteen feet, a smooth body, or but slightly haired, and dwell in leaves, which they roll up or convert into tunnels by means of silken cordage. They live upon the parenchyma of their own leafy dwellings, which thus serve them both for food and clothing. Others form their dwellings by uniting several leaves together, while a few are found in different kinds of fruits. Several have the posterior part of their body narrower than the others, and these were named *chenilles en forme des poisson* by Réaumur. Their cocoons are boat-shaped, and

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[1] The genus Noctua of Fabricius, as observed by Latreille in his note to the *Règne Animal*, t. v. p. 409, is, in Ochsenheimer's *Schmetterlinge von Europa*, divided into forty-two genera, from *Acronita* to *Euclidia* inclusive. These are constituted in great part by the conversion into genera of the sections previously indicated in the "Systematic Catalogue of the Lepidoptera of Vienna." Their insertion in this article would however be still more incompatible with our own limits than with those of the *Règne Animal*, from which they are expressly excluded. The Noctuæ, according to Latreille, exclusive of *Erebus*, are resolvable into two great parallel series, one of which is related to these latter Lepidoptera, the other to the Notodontæ. The first is composed of those of which the caterpillars march after the manner of the surveyors or Geometræ. Some have sixteen feet, of which the anterior two or four of the intermediate membranous ones are the shortest; others have only twelve feet, such as *Plusia* and *Chrysoptera*, genera distinguished from the preceding by the size of the inferior palpi, which are recurved upon the head. The second series commences with species of which the palpi are proportionally larger, the antennæ pectinated, and the trunk smaller;—such are *Notodonta palpina* (*Odonptera palpina*, Lat.) and the genus *Calyptra* of Ochsenheimer. Then follow the genera *Xylena* and *Cucullia*, those Noctuæ in which the posterior margin of the anterior wings are angular or dentated, those in which the antennæ are pectinated, and those in which they are simple. The latter species are terminated by such as have an even thorax, some of which, belonging to the genus *Erastia*, seem to lead to the Pyralites. All the caterpillars of this second series have sixteen feet, with the intermediate membranous ones of equal size; their mode of progression is rectigrade. The genus *Chrysoptera* (*Plusia concha* of Fischer, in *Entomog. de la Russie*, i. *Lepidop.* iv.), with which Latreille concludes the other series, is related to *Herminia* and *Pyralis*. Thus both series seem to converge towards the latter section. The *Licheniæ*, or *Catacolæ*, of Ochs., are large species, with almost horizontal wings, which, as well as *Ophiusa*, *Brephos*, &c. appear to approximate naturally to Erebus. Latreille is of opinion that if placed in the other series they destroy its harmony.

The *Bombyx cyllopoda* of Dalman (*Analect. Entom.* 102) ought to form a new sub-genus, and of a remarkable nature, in so far as the two posterior legs of the male are shorter than the others, unarmed, and almost useless for the purposes of locomotion. This insect has the antennæ pectinated, a distinct trunk, and the palpi as long again as the head, and ought therefore to be placed near the genus *Calyptra* of Ochs. or *Herminia* of Latreille.

[2] A beautifully providential change has been rendered natural to some of these species in relation to their food. The larva of *N. algæ*, Fab. is always yellow when it feeds on *Lichen juniperinus*, which is itself of that colour; but it becomes grey while pasturing on *Lichen saxatilis*.

[3] Réaumur, *Mém.* ii. 327; *Introduc. to Entom.* i. 189.

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are in some kinds formed of pure silk, in others of mixed materials. These insects compose the genus PYRALIS of Fab. (Plate CCXXXVII. fig. 16). Many of the species are destructive to fruit-trees and vines. *P. pomona* in the caterpillar state lives in the interior of apples, of which it eats the pippins. We may name as a British species *P. prasinaria*, which is the largest known. It measures about two inches in extent. The upper wings are pure green with two oblique streaks in the centre, the thorax is green, the under wings white. This species, with that which we have figured, form the genus *Chloephora* of Stephens.

SECTION 7TH, PHALÆNITES, Lat.

Here are comprised a numerous assemblage of nocturnal Lepidoptera, in which the body is usually slender, with the trunk either apparently wanting, or generally but slightly lengthened, and almost membranous; the inferior palpi are small and nearly cylindrical; the wings ample, extended, and almost horizontal, or flatly decumbent. The antennæ are pectinated in several males. The thorax is always even, or without a crest. The caterpillars have in general only ten legs, though some (*Ph. margaritaria*) have twelve; the anal pair are always present. These insects correspond to the *Geometræ* of Linn., and their peculiar mode of progression, already described in our observations introductory to the lepidopterous order, has obtained for them the name of *surveyors*. Their attitude in repose, also before described, is still more extraordinary.[1] They then resemble little broken twigs of the plant on which they rest; and their colours, and the inequalities of their surface, aid the deception. They thus no doubt frequently escape the observation of their natural foes. Roesel states that his gardener, mistaking one of these ligneous-looking larvæ for a dead twig, the brittleness of which he no doubt expected would admit of his instantly snapping it asunder, started back in the greatest alarm when he found by its consistence and motion that it was a living creature. The chrysalids are almost naked, their cocoons being thin and poorly supplied with silk.

According to Latreille's views, by which we are at present guided, this section, when considered in relation to the perfect insects alone, contains but a single genus, that of PHALÆNA properly so called (Plate CCXXXVII. figs. 13 and 15) of which the characters consequently agree with those just assigned to the section itself. A very different view, however, has been taken by the greater mass of entomologists, foreign and indigenous; and a roll of names of fearful length and deep construction, has been received by many as constituting a proper portion of our scientific nomenclature. Thus Mr Stephens' family *Geometridæ*, corresponding to the *Phalænites* of Latreille, contains above eighty British genera. The number is precisely eighty-three in Mr Rennie's *Conspectus*. Many naturalists believe that no such divisions as genera exist in nature, and consequently that all our generic distinctions are artificial, and constructed merely for convenience, as a helping instrument for ourselves, and an easier mode of mutual communication between ourselves and others. But all naturalists admit that there is a difference in the value of the characters chosen, and that such as are selected as generic should be pervading and influential over a pretty obvious group, not chosen arbitrarily or at hazard from the examination of the limited productions of any one confined insular region, but on mature deliberation, and after a kindly and extended study of the analogous productions of foreign lands. Characters drawn from form and structure are much less liable to accidental variation, and are likewise of more comprehensive application, than such as are derived from colour;—the former have consequently been used to distinguish the greater groups, including genera,—the latter are chiefly available in the discrimination of species, and their mode, range, and frequency of variation, of themselves afford most interesting subjects of study and reflection, in relation to the varieties of each particular kind. It is doubtful, however, whether the use of the evanescent shades of so superficial a character as colour, is advisable in the distinction of genera. The great test of a good generic character consists in its being in some way connected with or influential over the natural habits of the species which it is assumed to distinguish,—so that it may fairly be presupposed to exist in other species of similar instinctive modes of life. These traits are no doubt difficult to obtain in the insect creation, where the species are so numerous, and the gradations so often insensible from one group to another. But still we know that colour, though occasionally extremely characteristic of natural groups, is a distinction too flighty and fantastical to be generally applied with advantage, otherwise than for artificial combinations. For these and other reasons not necessary to be here adduced, we have hitherto failed to see the propriety of such characters as "first pair of wings somewhat rufous, with darker streaks," "second pair pale, with a red streak," "wings banded with green," "the first pair greenish, spotted with black, the second pair dull," &c. being adopted as *generic* distinctions,—the more especially as they would prove not very efficient even for the purposes of *specific* discrimination.

There is no doubt, however, that the great extent of the genus in question requires that it should be reduced by subdivision within manageable bounds; and if determinate and distinctive characters of sufficient value can be attached to each, a generic name may as well be used as a sectional mark. Hubner has described and figured above 400 European species, and MM. Lepelletier de Saint Fargeau and Serville have formed numerous divisions among the species described by them in the *Encyclopédie Méthodique*. Modern entomologists have adopted a method of distinguishing by the specific name alone, whether the male of a phalæna has the antennæ pectinated or setaceous. The names of such as exhibit the former structure always end in *aria*, those characterized by the latter in *ata*. A very common species is *Ph. Grossulariata*, white, with some yellow streaks, and spotted with black. The caterpillar is also richly coloured. It feeds on the leaves of the currant and gooseberry. The chrysalis is of a shining black, with yellow rings. It is known in England by the name of Magpie. *Ph. ulmata*, or the clouded Magpie, is a scarcer species. In Scotland at least it is rare. Both these belong to the sub-genus *Abraxas* of Leach. A rather large and elegant species, called the swallow-tailed moth, *Ph. sambucaria*, is of a pale sulphur colour, with two transverse streaks upon the upper, and one upon the under wings. It forms the sub-genus *Ourapteryx* of Leach, and resembles in its form the beautiful *Phalæna machaonaria* of Boisduval, which, with *Ph. guttaria*, ibid. we have represented by the figures last referred to. The females of a few present only the rudiments of wings. Such is *Ph. brumata*, which makes its appearance during the winter season, and belongs, for that reason, to the sub-genus *Hybernia* of Latreille.

SECTION 8TH, DELTOIDES, Lat.

This section consists of species very analogous to the true Phalænæ, but the caterpillars have fourteen legs, and live in rolled up leaves. The inferior palpi are elongated and recurved in the perfect insect. The wings form with the body, on the sides of which they spread horizontally, a kind of delta, with a re-entering angle in the middle of the posterior edge, producing a forked aspect. The antennæ are usually pectinated or ciliated. Our present section comprised, in the first edition of the *Règne Animal*, all the *Phal. Pyralides* of Linn. But, as Latreille has more recently observed, a complication of characters resulted from that arrangement, which is obviated by only comprising in this division the genus HERMINIA (Plate CCXXXVII. fig. 17), which belonged to *Pyralides* of Linnæus, and is composed of the genus *Hyblæa* of Fab. and several species of his genus *Crambus*. These Lepidoptera are generally of a greyish hue, without much brilliancy of colouring. Several species are remarkable for tufts of hairs upon the upper portion of their legs, the use of which in their natural economy has not yet been ascertained. Indeed we know little of the history of the species, although they sometimes attract our notice by the length of their palpi. They have been named *snouts*, *fan-feet*, &c. by the English collectors.

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[1] See page 239.

SECTION 9TH, TINEITES, Lat.

Latreille here comprehends the *Phal. Tineæ* of Linn. and the greater part of the *Phal. Pyralides* of the Swedish naturalist. They consist of the smallest species of the lepidopterous order,—among others, of our common house-moths, so well known for their destructive propensities in the larva state, and the ravages they commit among neglected garments. These larvæ are smooth, have always at least sixteen feet, and live concealed either in fixed or moveable habitations, of their own construction. In some the wings form a kind of elongated triangle, almost flattened, and terminated by a re-entering angle;—such are the *Phalænæ Pyralides* of Linn. They have four distinct and usually exposed palpi. In others the superior wings are long and narrow, sometimes moulded on the body, and forming over it a rounded roof,—sometimes inclined almost perpendicularly, applied close to the sides, and frequently elevated posteriorly after the manner of a cock's tail in miniature. In either case the inferior wings are always broad and plaited. The latter kinds also have not unfrequently four exposed palpi.

All nocturnal Lepidoptera, the caterpillars of which lived in sheaths or cases, received from Réaumur the name of *Teignes proprement dites* or of *Teignes fausses*, according as their habitations were detached and portable by the contained creature, or fixed and immoveable.[1] This principle of arrangement, though sufficient for the purposes which the admirable author had in view, is not philosophically founded, and, if strictly applied, would require our including among the Tineites the genus *Pyralis* and others belonging to preceding sections. In the Linnæan system, our present insects composed the seventh division of the great genus Phalæna, and were briefly characterized as follows:—Wings almost cylindrically rolled, front projecting. They constitute a generic group in Geoffroy's work.[2] Following the example of Linnæus, Degeer did not separate these small creatures from the general mass of Phalænæ, but satisfied himself by forming them into different sections of his fourth and following family. Indeed his arrangement of the Phalænæ is extremely artificial.

The Tineites, although they are the pygmies of the lepidopterous order (what a vast disparity in size between a small clothes-moth and the great owl-moth of Brazil!) are much more richly attired than most of their larger brethren. Indeed, when minutely examined, not many created things will be found more worthy of our admiration; and it is not without reason that Scopoli has observed,—"Tinearum copia, parvitas, pulchritudo stupenda, ut in his potissimum natura thesauros suos effudisse videatur, tantaque in minimis hisce majestas, ut admirari potius eam liceat, quam aptis verbis indicare."[3] The wings frequently combine, with extreme beauty of colouring, the most brilliant little stripes and masses of shining silver and burnished gold, which under the microscope exhibit a most radiant richness. This lustrous aspect of many species is however but a poor recompense for the injury which we receive from many more while in the larva state. These clothe themselves at our expense in the warmest woollen garments, which they traverse in all directions, leaving behind a gnawed and worn-out path, so thin and bare as to yield to the slightest pressure. They also destroy furs, hair, feathers, and many other articles of domestic economy, and are the exterminating pests of zoological museums. To them we no doubt owe the destruction of the famous Dodo, once preserved in the Ashmolean Museum of Oxford, and never since seen by human eyes. By means of their maxillæ these little larvæ shear down the surface of various substances, and uniting the particles by means of their glutinous silk, they thus form protecting habitations, which partake of the nature of the woollen or other stuffs on which the foresight of their parents has placed them. When they themselves increase in bulk, so as to find their abodes as inconvenient as a strait waistcoat, they split them down the middle, and interpose a piece, proportioned no doubt to their expected as well as actual increase. They add to the length also by fresh materials to the anterior end. These observations are easily made by removing the young larva in its first restricted case, from a piece of white to a piece of scarlet or other coloured flannel. When about to undergo their transformations they close up the apertures with silk. Another larva of this section (*Teigne des blés*), which Olivier makes an *Alucita* and Latreille an *Œcophora*, is still more destructive on account of its ravages among corn, and its prodigious powers of multiplication. Our grain is also liable to great damage from the larvæ of other Tineæ, such as the *fausse chenille des blés*, described by Réaumur, which, by means of its silken web, connects together several grains in the form of a tunnel, from which it issues forth to feed on the neighbouring heaps. It is a somewhat analogous species which in bee-hives pierces the waxen cells on which it feeds; and by thus causing the honey to flow out, occasions great loss to the apiarian. Our readers must have frequently observed the leaves of many plants and trees pervaded by numerous tortuous windings, of a paler colour than the rest. These are the sub-cutaneous galleries of certain very small larvæ of garden-moths, many of them extremely beautiful, and so minute as to dwell at ease between the upper and under surface of the leaf. Others dwell and feed upon the surface, but screened from immediate observation by a covered way of silk, which they spin along their devious courses. Referring the curious reader to the works of Réaumur, Roesel, and Degeer, for a more ample history of these truly singular and interesting tribes, we shall here briefly notice a few of the principal genera.

In the following groups the four palpi are always dis-

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[1] The *Teignes aquatiques* of Réaumur are the larvæ of *Phryganeæ*; and those to which he applies the ancient name of *Ligniperdæ* are the larvæ of the genus now called *Psyche*, belonging to the section *Pseudo-Bombycites*.

[2] *Histoire des Insectes des Environs de Paris.*

[3] *Entomologia Carniolica*, p. 243.

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tinct,[1] exposed, or simply concealed (the upper ones), in part by the scales of the epistoma, and are advanced, of medium size, and analogous to those of the *P. pyralides* of Linn. Their wings are decumbent, generally flattened, or but slightly raised, and form a kind of delta or elongated triangle. In the ensuing genera the trunk is apparent, and serves for the performance of the usual functions. The larvæ live on various plants. In Botys, Lat. (CCXXXVII. fig. 11), the larvæ roll up leaves, and do not differ externally from the others except in the respiratory organs. In Hydrocampe, Lat. (ibid. fig. 12), the species are analogous to the preceding, but the caterpillars are aquatic, and are usually furnished with filiform appendages, the interior of which contain tracheæ. They fabricate tunnels or covered ways with the leaves of various aquatic plants. Such are *H. potamogata*, *paludata*, *lemnata*, &c. In the genus Aglossa of Lat. (ibid. fig. 19) the trunk is wanting, or nearly so. The four palpi are exposed, and the wings form a flattened triangle,—the upper having no emargination at their extremity. *A. pinguinalis*, Réaum. iii. xx. 5–11, occurs on walls in houses. The caterpillar is smooth or short-haired, of a brownish black, and shining. It feeds on various fatty substances, and also attacks leather,—on which account it is called *fausse-teigne des cuirs* by Réaumur. It is destructive to the binding of books, and is therefore an inconvenient companion in a library. Its case consists of a long tunnel, applied close to the substance on which it lives, and covered by particles of excrementitious matter. According to Linnæus, it occurs, though rarely, in the human stomach, where it occasions effects much more dangerous and alarming than those caused by ordinary intestinal worms. " Un médecin éclairé, " says Latreille, " et dont je ne puis révoquer en doute la véracité, m'a envoyé des chenilles de cette espèce, qu'une jeune famille avait vomies." Another species, *P. farinalis*, feeds on flour. In the genus Galleria of Fab. the scales of the clypeus or epistoma form a projection which covers the palpi. The upper wings, proportionally narrower than those of Aglossa, and emarginate on the posterior border, are, in common with the inferior, very decumbent, and raised posteriorly like a cock's tail, as in many species of the ensuing genera. *G. cereana*, Fab. is the species the larva of which is designated *fausse-teigne de la cire* by Réaumur. It is extremely destructive in bee-hives, in which it pierces the honey cells, and constructs as it advances a silken tunnel covered with excrementitious particles composed of the wax which it has devoured. The cocoons of the chrysalids are sometimes found assembled in heaps.

In other groups of Tineites the superior palpi are not always very distinct. The upper wings are long, narrow, sometimes moulded or rolled upon the body, sometimes applied perpendicularly to the sides. In this state the insect has always an elongated and narrow form, approaching that of a little cylinder or cone, when the wings are closed.

In the next-named four genera the inferior palpi, always large, are borne, as it were, in advance, the last joint at most being raised. The palpi are apparent. Crambus, Fab. (Plate CCXXXVII. fig. 20), has a distinct trunk. The inferior palpi project straight forwards like a beak. These Lepidoptera occur in dry pastures and on various plants. Alucita, Lat. (ibid. fig. 22), has also a distinct trunk, but the inferior palpi are raised. The antennæ are simple. In Euplocampus, Lat. (ibid. fig. 18), the trunk is short and inconspicuous, and the last article of the inferior palpi is likewise raised, the scales of the preceding one forming a faisceau. The antennæ of the males are furnished with a double row of little barbs. The genus Phycis of Fab. is closely allied to Euplocampus, but the antennæ at most are merely ciliated.

In the following genera the inferior palpi are entirely raised, and even recurved over the head in several. Sometimes the inferior palpi are very apparent, and of medium size. The antennæ and the eyes are distinct. In the two following genera the inferior palpi scarcely surpass the front. In Tinea (ibid. fig. 21) the trunk is very short, and formed of little membranous disjointed threads. The head is erected. The species of this genus, which has been greatly restricted since the time of Fabricius, are particularly destructive among our clothes and other household concerns. We shall here notice a few of the principal kinds. *Tinea tapezana*, Fab. and Lat., has the upper wings black on the basal portion, their posterior part being white. This is the species represented by our figure.[2] Its caterpillar feeds on woollens, on which it forms an arched gallery, lengthening as it advances. *T. sarcitella* is of a silvery-grey colour, with a white spot on each side of the thorax. Though very abundant and extremely destructive in most parts of Europe, its synonymy and consequent history are somewhat confused. The figures given by Réaumur,[3] and cited by many authors, appear (at least if we judge from the eleventh) to belong to another genus. The inferior palpi are large, recurved and pointed, a character which rather allies it to the genus *Volucra* of Lat.[4] and to the *T. vestianella* of Scopoli and Linn. It is even suspected that these two insects are the same. According to the last-named authority, the *T. sarcitella* is of a silvery grey, as above described. In *T. vestianella* the upper part of the head, of the thorax, and even the base of the superior wings, are white. The inferior palpi, recurved in the manner of horns, are of the same colour, ringed with black. The wings lie horizontally on the body, are whitish, and shining, and the upper surface of the superior pair presents some blackish spots of different sizes. The inferior are of a uniform colour, bordered posteriorly, as is also the internal margin of the upper pair, with long fringes. This species is extremely common, and it has been presumed that Linnæus having given an inadequate description from a defective specimen, its identity became difficult to recognise, and that thus Scopoli bestowed a new name, that of *vestianella*, upon an old species.[5] However this may be, the *T. sarcitella* is extremely pernicious among all woollen substances. It forms and inhabits a silky case, usually spindle-shaped, which it covers with detached hairs or particles of wool. *T. pellionella*, Fab. has the upper wings of a silvery grey, with one or two black points on each. Its caterpillar forms a felted case or tunnel, and lives on furs, which it destroys with ease and satisfaction to itself, by gnawing off the hairs at the base. The wings of *T. granella* are elevated behind, and marbled with grey, brown, and black. Its larva is very injurious to grain. *T. flavifrontella*, Fab. has a *toupee* of a more lively colour than the other parts, approaching to reddish. Its larva forms a silken case, and is extremely hurtful in museums, among birds, insects, &c.

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[1] The genera *Iponomeuta* (with one or two exceptions), *Œcophora*, and *Adela*, are, according to Latreille, the only Tineites of which the superior or maxillary palpi are not distinctly perceptible; but as they may be concealed by the inferior or labial palpi, it is difficult, in relation to this point, to establish a fixed and rigorous line of demarcation. For this reason the French entomologist has not arranged the Tineites according to the number of the palpi. M. Savigny, in his *Memoires sur les Animaux sans Vertèbres*, has given figures, in which these parts are represented in their various proportions. (*Règne Animal*, v. p. 417.)

[2] It is identical with *T. tapetzella* of Linn. and the lamented Mr Haworth.

[3] *Mémoires*, iii. vi.

[4] *Règne Animal*, t. v. p. 412, note.

[5] See *Dict. Classique d'Hist. Nat.* xvi. p. 87.

We may conclude by observing, that the most efficient means of preventing or removing moths are care and cleanliness. Let articles of such a nature as may be liable to their injurious inroads be frequently examined, handled, and exposed to light and air. These tiny creatures are lovers of darkness, and of undisturbed repose. The instinct of the mother (and that providential perception is never more unerring than when manifested in relation to the welfare of a future offspring) teaches her to distinguish whatever is neglected or cast aside,—and in like manner she becomes sensible that whatever is used or often handled would form an unsafe nidus for her tender young. In depositing her eggs she therefore selects the one and rejects the other; and hence a careful housewife, who feels a lively interest in her own concerns, and frequently examines and refolds or arranges her household gear, may live for half a century and never see a moth. At the same time, if articles are rolled up in a perfectly close and well-ordered tissue, they are safe from these destructive creatures, which are certainly never *bred* from the things they consume, however old or ill-conditioned. But if a single unsuspected crevice should chance to admit one solitary female moth, "the spinster's occupation's gone," and a colony of worms is suddenly produced from innumerable eggs, which would strike horror into the heart of a Malthusian. Where things must be left unexposed to changes of light and air, and yet cannot be hermetically closed, the use of camphor, spirit of turpentine absorbed upon pieces of sponge or cotton, and other preventives, are tried with more or less success. Exposure to a brisk fire is the most effectual means of expelling the larvæ from stuffed birds, quadrupeds, &c.

In the genus ILITHYIA, Lat. (Plate CCXXXVII. fig. 23), the inferior palpi resemble those of the preceding genus, but the trunk is distinct, and of the ordinary size, and the last article of the inferior palpi is obviously shorter than the preceding. In IPONOMEUTA, Lat. (ibid. fig. 24), the trunk is also distinct, and of tolerable size, but the terminal article of the inferior palpi is at least as long as the preceding one. These insects, according to Latreille, are related to Lithosia. *Y. evonymella* (Tinea of Fab.) has the upper wings of a shining white spotted with black, the inferior pair lead colour. *Y. padella*, Lat. has the upper wings of a greyish-lead colour, and very numerously spotted with black, the under pair lead coloured, with thick fringes. The caterpillars of both these kinds live in large congregations, beneath a dusky web, which they stretch out upon our fruit-trees, of which they devour the leaves. When they have eaten all within their reach at one place, they make a start to another, enclose themselves under a new and more extended canopy, and recommence their ravages, which are found to be extremely injurious to the health of the tree, and its productive powers. The branches seem as if covered with patches of dusty and discoloured crape. In the genus ŒCOPHORA, Lat. the inferior palpi are recurved above the head, in the manner of horns, proceeding to a point, and reaching as far backwards as the back of the thorax.

Lastly, in a few species, such as those of the genus ADELA, Lat. (Plate CCXXXVII. fig. 25), the inferior palpi are very small and clothed, the antennæ are almost always extremely long, and the eyes approximate. These beautiful little creatures occur in woods, and are said to appear with the leafing of the oak. They are frequently brilliantly ornamented with metallic scales. The species which we have figured is *A. Degeerella*, remarkable for its antennæ being many times the length of its body. These delicately articulated organs are whitish, the posterior portion black. The upper wings are of a gilded yellow on a dark ground, forming longitudinal streaks, with a broad transverse golden-yellow band bordered with violet.[1]

SECTION 10TH, PTEROPHORITES, Lat.

This, our concluding section of the nocturnal Lepidoptera, exhibits many relations to the preceding, in respect to the narrow and elongated form of the body and upper wings; but it differs from it, as well as from all the other sections, in this, that a pair, if not all, of the wings, are as it were split or cloven throughout their whole length, so as to present a branched or digitated appearance, bearded on the edges. The parts look like feathers, so that the wings of these fantastically formed creatures somewhat resemble those of birds. They formed the division of *Phalænæ alucitæ* of Linnæus, and were named Phalènes-tipules by Degeer. Geoffroy, Fabricius, and Latreille include them under the genus PTEROPHORUS. Their larvæ have sixteen feet, live on leaves and flowers, and construct no cases. The chrysalids of the greater number are naked, coloured, and suspended by a thread. In others they are enclosed in a translucent cocoon. The genus has been lately subdivided. In some the inferior palpi are recurved from their origin, entirely garnished with small scales, and do not exceed the length of the head; these constitute the genus PTEROPHORUS properly so called, of Latreille (Plate CCXXXVII. fig. 26). Their chrysalids are exposed, beset with hairs or small tubercles, and are sometimes suspended by a thread, sometimes fixed by means of hooks at the posterior extremity to a little bed of silk, imposed upon a leaf or other vegetable body. *P. pentadactylus*, Fab. is an example of this division. The wings are of an almost snowy whiteness, the upper pair being divided into two, the lower into three parts. In others the inferior palpi are projected, longer than the head, with the second article thickly covered with scales, and the terminal one almost naked, and turned up. The chrysalis is enclosed in a cocoon of silk. To these Latreille has applied the generic name of ORNEODES (ibid. fig. 27). The *O. hexadactylus* measures about six lines in length. It is of an ash-coloured grey, with a tinge of brown. The wings, especially the upper ones, are traversed by obscure or blackish bands, with some spots of a paler grey; and each wing is divided to its base into three principal parts, of which the first is subdivided into two radii, and the second into three: the third is simple. The caterpillar of this species has sixteen feet, and lives on the honeysuckle, *Lonicera xylosteum*. The perfect insect is often found on walls and windows, and in the interior of houses. It is widely spread over Europe.

We here take leave of the lepidopterous order, and shall only further remark, that we seek in vain to express by words the splendid colours, the elegant and varied forms, and the exquisite pencilling, by which they are adorned. Even the most richly illumined pages of natural history convey but a meagre image of their gorgeous attire. That must be sought for—where alone it can be found,—in those far more brilliant and inimitable pages of the *book of nature*, in which the most successful effort of art is transcended by a feeble insect's wing. The imagination of poet and of painter cannot boast,

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[1] In the arrangement of these insects, given by Latreille in the second edition of the *Règne Animal*, and by which we have been guided above, he has apparently, with the view of approximating to the nomenclature of Réaumur, combined the *Pyralides* and *Tineites* in one section. He has however elsewhere indicated the propriety of their being disjoined, and in this event the following genera will compose the Tineites: I. Inferior or labial palpi advanced; the terminal articulation at most elevated; superior palpi apparent: Genera GALLERIA, CRAMBUS, ALUCITA, EUPLOCAMPUS, and PHYCIS. II. Inferior palpi altogether elevated, or even recurved, in several, over the head. A. Inferior palpi of medium size, and very obvious; eyes distant: Genera TINEA, ILITHYIA, IPONOMEUTA, ŒCOPHORA. B. Inferior palpi very small and hairy; eyes approximate: Gen. ADELA.

> Amid their gay creation, hues like these.

ORDER VII.—STREPSIPTERA, KIRBY.[1]

The singular insects which constitute our present order are parasitical species, which dwell, while in the larva state, between the plates of the abdomen in different kinds of wasps and bees. Their characters were first given by Mr Kirby (*Linn. Trans.* vol. xi. p. 109), who bestowed upon them the name above adopted, and which was subsequently altered, without sufficient reason, by Latreille. The definition given by the former author, in his later work, is as follows: Metamorphosis sub-incomplete? Pseudelytra twisted, attached to the anterior leg. Wings not covered by the elytra, longitudinally folded, forming nearly the quadrant of a circle: neuration simple. Anus styliferous.[2] On each side of the anterior extremity of the thorax, near the neck and the exterior base of the first pair of legs, are inserted two small crustaceous bodies, like rudimentary elytra, stretching backwards, curved, dilated, and terminating near the origin of the true wings. These are the *pseudelytra* just named, called *prebalanciers* by Latreille. The great French entomologist is of opinion, that, as elytra properly so called always cover the totality of the base of the membranaceous wings, and derive their origin from the second segment of the thorax, the parts in question are not genuine wing-cases, but rather analogous to the tippets (*pterygoda*), observable at the base of the upper wings in the lepidopterous order. The actual wings of Strepsiptera are large, membranaceous, divided by longitudinal nervures, proceeding like rays from the shoulder or point of union with the body. They fold lengthways like a fan.[3] The mouth is composed of four pieces, of which the shorter two appear to be biarticulate palpi, the others, inserted near their base, have the form of little linear laminæ, pointed, and crossing at the extremity, like the mandibles of various insects, but resembling rather the lancets of the sucker of the dipterous tribes, than true mandibles.[4] According to Savigny's views, the mouth consists of a labrum, two mandibles, a pair of maxillæ, each bearing a very small uniarticulate palpus, and a labium without palpi. The head presents two large eyes, hemispherical, granose, and slightly pediculated; two antennæ, approximate at the base, placed upon an elevation in common, almost filiform, short, and composed of three articulations, of which the first two are very short, and the third, greatly elongated, is divided from its origin into two long compressed lanceolate branches, applied against each other. The stemmatic eyes are wanting. The thorax, in its peculiar form and divisions, resembles that of several Cicadariæ, Psyllæ, and Chrysides. The abdomen is nearly cylindrical, composed of eight or nine segments, and is terminated by pieces which seem to bear an analogy with those which we find at the posterior extremity of the Hemiptera above named. The six legs are almost membranous, compressed, nearly equal, and terminate in filiform tarsi, composed of four membranous articulations, which appear vesicular at their extremity, and of which the terminal one, somewhat larger than the others, is unfurnished with hooks. The four anterior legs are approximate, the posterior pair being thrown pretty far back by themselves. The space comprised between the latter pair is ample, and divided into two by a longitudinal groove or furrow. The posterior extremity of the metathorax is prolonged over the abdomen in the manner of a large scutellum, and its sides, which serve as points of insertion to the posterior legs, are much dilated backwards, and form a kind of inflated buckler, which defends the exterior and lateral base of the abdomen.

These singular insects were first observed by Rossi, who concluded, because they were parasitical, that they must belong to the hymenopterous order, to which they certainly bear a greater affinity than to any of the dipterous tribes, among which they were arranged by M. Lamarck. Latreille inclines to consider them as related (although at the same time differing in various ways) to certain hymenopterous species, such as those of the genus EULOPHUS. In the larva state they live between the abdominal plates of hymenopterous insects belonging to the genera *Andrena* and *Polistes*. It has been supposed that the elytra-like portions, already described, serve to disengage the perfect insects with greater facility from the living chambers in which they are incased. They are said to frisk about with a simultaneous motion of these organs and the true wings. Latreille calls them the *Œstri* of insects. We know that a species of Conops likewise undergoes its transformations in the interior of a Bombus, or wild bee.

This order contains only two genera,—XENOS of Rossi, and STYLOPS of Kirby. Their exact nature is still of difficult determination, as will be perceived from the following quotation:—"The true place in nature," says Mr Macleay, "of the singular genera *Xenos* and *Stylops*, is indeed very difficult to determine; and what remarks, therefore, I am now about to offer on them ought to be received by the reader with great caution, as well because it has hitherto been out of my power to become acquainted with them, except through the medium of the works of Kirby, Latreille, Savigny, and Lamarck, as because the total variance in the statements of these authors respecting them demonstrates that their true nature is as yet by no means ascertained.

"Professor Peck and Savigny, however, have both most satisfactorily shown that the *Strepsiptera* are provided with true mandibles and palpigerous maxillæ; and therefore have completely set aside the opinion of MM. Lamarck and Latreille as to their affinity with the *Diptera*. Proceeding, then, on the fact that they belong to the *Mandibulata*, which, by the by, appears at last to be admitted by Latreille, we necessarily make inquiry as to the particular part of this class in which they ought to be placed. Now, the only chasms of importance which we have noticed in the column, are one between the *Trichoptera* of Kirby and the *Tenthredines*, and the other between the *Hymenoptera* and the *Coleoptera*. The deficiency of ocelli, the structure of the whole insect, but particularly that of the wings, prove that the *Strepsiptera* cannot occupy any vacancy near the *Trichoptera*. It therefore only remains for us to place them between the *Hymenoptera* and *Coleoptera*. But this appears to be nearly the situation originally given to the *Strepsiptera* by Mr Kirby; for, in his very remarkable paper on those insects, in the eleventh volume of the *Linnæan Transactions*, he says, 'With respect to the place of *Strepsiptera* in the system, it seems to me that this order should follow *Coleoptera*; for its metamorphosis being different from that of *Orthoptera* and *Hemiptera*, and nearer to that of the *Coleoptera*, this seems its most natural station, considered as an elytrophorous order, especially since, if it be inserted between *Orthoptera* and *Hemiptera*, with both of which it has some affinity, it would interrupt the series of semicomplete metamorphosis, by which, besides other characters, these two orders are so closely united.' He had previously noticed a circumstance which at once distinguishes them from all *Coleoptera* and *Orthoptera*, and gives them an affinity with the *Hymenoptera*, namely, a narrow collar instead of an ample thoracic shield. And it is worthy of remark that Rossi, in the work which informed naturalists of their existence, placed them among the *Hymenoptera*, induced to this, as Mr Kirby supposes, by the economy of their larvæ. Such, then, is in all probability their true place in nature, though certainly my opinion on the subject, for the reasons already stated, ought to be received, as it is advanced, with great caution. The *Xenos*, beyond a doubt, is, with the *Stylops*, the most puzzling insect to place naturally that we know; it is truly '*animal animum excrucians*;' and no better proof of this can be given than that when Lamarck and Latreille make the *Strepsiptera* a division of *Diptera*, they seem absolutely to have pitched on the most artificial situation for them which they could have chosen. Latreille has remarked that the body of the *Strepsiptera* bears a striking relation to that of some *Homoptera*; and to judge from the descriptions given by Mr Kirby of these insects, their wings are folded like those of *Orthoptera*, while the form of their head resembles that of some *Neuroptera*. To the *Diptera* they have no visible affinity, and scarcely any analogy, except such as we might expect from their proximity to the *Hymenoptera*. How far I am right in adopting Mr Kirby's opinion as to their real affinities, remains yet to be seen; but it is no weak argument in support of its accuracy, that they possess the very precise kind of metamorphosis which insects in the hiatus between the *Coleoptera* and *Hymenoptera* ought to have from analogy.

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[1] RHIPIPTERA, Lat.

[2] *Introduc. to Entomology*, iv. 370.

[3] Hence the name of *Rhipiptera*, bestowed upon them by Latreille, from ϱιπις, *a fan*, and πτεϱα, *wings*.

[4] *Règne Animal*, v. 425.

"The *Strepsiptera* ought probably to be considered as an osculant order; and they undoubtedly form a group which is apparently of much greater importance, and is marked with much stronger characters, than the *Dictuoptera*. These can scarcely be said to afford a type of any very peculiar construction, and may therefore, perhaps, with more propriety, be viewed as an annectent tribe falling into the extensive order of *Orthoptera*."[1]

In the genus STYLOPS, the last portion of the antennæ is composed of three small articulations. The abdomen is fleshy and retractile. *S. Melittæ*, Kirby, measures about a line and a half in length, and is quite black, with brown legs. The wings are longer than the body. The larva is soft, almost cylindrical, and whitish. Its head is advanced, horny, heart-shaped, a little flattened, of a reddish colour, black posteriorly, and somewhat concave beneath. It lives in the bodies of *Andrenæ*, and when about to be transformed to a chrysalis or pupa (Plate CCXXXI. fig. 29), it fixes itself more outwardly, between the abdominal plates. It occurs in Britain and the continent of Europe. Additional species have been lately discovered by Mr Dale and others, and will be found described in the works of Messrs Curtis and Stephens.

In the genus XENOS established by Rossi,[2] and so excellently illustrated by Mr Kirby,[3] the terminal branches of the antennæ are not articulated. The abdomen is corneous with the exception of the termination, which is fleshy and retractile. We are acquainted as yet with the detailed history of only two species. The first is the *Xenos vesparum*, now called *X. Rossii*, in compliment to its discoverer. It inhabits, and is frequently found in, a European hymenopterous insect or wasp called *Vespa* (*Polistes*) *gallica*. The individuals of the latter kind infested by the Xenos are readily known by the unnatural swelling of the fourth segment of the abdomen, from which the insect in the perfect state is usually found to emerge. Sometimes one, not seldom two, and occasionally three, are seen to escape from the same wasp. They generally come forth in the winged state in August and September; and if during that period the pupa be extracted with a needle from the abdomen of the wasp, the covering broken open, and the white tunic carefully stripped away, living specimens may be obtained. The mode in which these parasites are originally placed on their living prey is not yet known. It is possible that the egg may be laid in the larva of the wasp before its cell is closed. Rossi at least seems to be of this opinion, although Mr Kirby, reasoning from analogy, thinks it unlikely that it should be deposited on the wasp in its first state, while the larva feeds on it in its last. It has been a subject of wonder to naturalists that these Vespæ, after supporting one or more parasites, should survive; yet we know that they are often met with in a most active and vigorous condition, with only the exuviæ of the Xenos remaining in them. It has been stated as an explanation of this, that the time during which the insect remains in the larva state is very short; and as it does not attack the thorax of the wasp, the muscular energy and general vital powers of the latter thus escape destruction. The other species to which we alluded is the *X. Peckii* (Plate CCXXXI. figs. 30 and 31), so named after an American naturalist, Professor Peck, by whom it was made known to Mr Kirby. This species measures one and a half lines in length. It is of a blackish-brown colour, the legs livid, the tarsi brown. The branches of the antennæ are subdiaphanous, and spotted with white. The larva inhabits a North American wasp called *Polistes fuscata*, of which it so distorts the abdomen that, according to Professor Peck, there is no difficulty in distinguishing the infested individuals even on the wing. "Taking them," he observes, "with the gauze forceps, bringing them into a close room, and permitting them to fly to the windows, I caught them again with a wine glass and a card, fed them with sugar, and thus preserved them till their parasites were disclosed. I had not the pleasure to see them emerge, but found them soon after." "In the feeding state the head of the larva is near the abdomen of the wasp, as I found by dissection. When the feeding state is passed, it is easy to conceive that it turns, and with its flattened head separates the membrane which connects the abdominal scuta, and protrudes itself a little way, accurately closing the aperture, which is but just large enough to admit it. All this time the wasp is active, and associates with its companions. When just protruded, the head of the larva is of a pale-brownish colour; by degrees it assumes a rounder form, and becomes almost black. The chrysalis state ensues; but I suspect that only the part exposed to the air, and that immediately under the pressure of the abdominal rings, becomes hard."[4]

We shall now pass from this limited order to one of much greater extent and more ancient constitution.

ORDER VIII.—DIPTERA.[5]

The numerous order of dipterous or two-winged insects, of which the common house-fly affords a familiar example, is characterized by possessing a pair of veined and membranous wings, with two moveable bodies called balancers (*halteres*) placed a little behind them. The mouth consists of from two to six setaceous pieces of a scaly texture, and its parts are either enclosed in the upper groove of a probosciform sheath, terminated by two lips, or covered by one or two inarticulate laminæ, which form the sheath.[1]

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[1] *Horæ. Ent.* p. 370.

[2] *Faun. Etrusc. Mant. Append.* p 114.

[3] In his essay *On a new Order of Insects*, *Linn. Trans.* vol. xi. p. 86.

[4] *Linn. Trans.* vol. xi. p. 90.

[5] ANTLIATA, Fabricius.

Dipterous species, like all other hexapod insects, are composed of three principal portions. The head is more or less globular or hemispherical, often concave posteriorly, so as to fit better on the front of the thorax, and is susceptible of turning on itself, as on a pivot, from right to left, and *vice versa*. The greater part of its surface, especially in the males, is generally occupied by the eyes, which are often very beautiful, being composed of a vast number of facettes, lighted up as it were with a metallic splendour. When ocelli or stemmatic eyes exist in this order, they are always three in number, and placed upon the vertex. When the mouth (which is not adapted for chewing or bruising solid substances, but only for extracting and transmitting fluids) consists of six pieces, it then exhibits all the parts analogous to those of masticating insects. Of these parts a single superior portion represents the labrum, and a single inferior portion the ligula properly so called, of the coleopterous and orthopterous orders. The four other parts are disposed in pairs; the upper pair corresponding to the mandibles, the lower to the terminal portion of the maxillæ of the masticating orders. The basal portion of the maxillæ also exists, but it is always very short, and confounded with the fleshy mass, which serves as the base of the trunk, and precedes its first geniculation. Thus in the Muscides, for example, the sucker consists of only two setæ, and is yet accompanied by a pair of palpi, which, according to analogy, can only be those of the maxillæ. Seeing that the piece representing the labrum is inserted, with the other portions of the sucker, near the geniculation of the trunk, and at some distance from the anterior margin of the head,—and that, in other insects, the labrum is always fixed to that margin,—it becomes necessary that a portion of the base of the clypeus, or epistoma as it is now called, should be incorporated with the support of the sucker. We have just stated that the inferior portions of the maxillæ are likewise united with the supporting part, which, when not in action, is withdrawn into the oral cavity. It is not thus with the Lepidoptera and Hemiptera,—the corresponding portion of the maxillæ in these orders being fixed and immoveable, and the labrum always preserving its relative position. In some Diptera the sucker is composed of only four pieces, and then the *mandibular* setæ are wanting or imperceptible. Indeed in a great number we perceive only two pieces, and in that case it is the single pieces only (*impaires*), that is, the labrum and ligula, which are cognisable. The reduction in the number of these parts is, according to Latreille, a proof of the inferiority of the dipterous order, when compared with the generality of insects. The sucker in our present order performs the office of a lancet, by piercing the envelope of vegetable fluids, or the vessels which contain the juices of animals. These liquids, by pressure of the parts, are then forced to ascend the internal canal to the pharynx, situate at the inner base of the sucker. The lancets are often grooved or furrowed, by which they become more compactly enclosed, and act in common. The sheath or external part merely serves to maintain the lancet *in situ*, and seems to represent the lower lip of the triturating orders. It is frequently bent upon itself, at an angle more or less acute, when the insect is using the sucker. This becomes obvious when we examine a gnat or mosquito in the act of pumping our blood.

The antennæ of the Diptera are usually inserted on the front, and are approximate at their base. In the family called Nemocera by Latreille (*Culex* and *Tipula*, Linn.), these organs resemble those of the nocturnal Lepidoptera in form and position, but in his other families they seldom consist of more than two or three articulations, the last of which is fusiform, or shaped like a lenticular or prismatic pallet, provided either with a little styliform appendage or a thickish hair or seta, itself sometimes simple, sometimes pilose.

The thorax appears as if composed of only a single segment, the first, or prothorax, being very short, or sometimes evanescent, and the metathorax being also very short, and occupying only the posterior extremity, situate beneath the scutellum. The mesothorax, or intermediate portion, thus becomes the principal apparent segment. It bears on each side a pair of stigmata, of which, however, the anterior is frequently alone distinguishable.

The neuration of the veins of the wings is simple. These parts are usually horizontal. Meigen's figures of the wings (of which we have availed ourselves in the plates connected with this article) are extremely exact. He confines himself, however, chiefly to the antennæ in the formation of his generic characters, without having recourse to Jurine's method of employing the neuration of the organs of flight,—a method, indeed, the application of which in the dipterous tribes is attended with greater difficulties than among the hymenopterous order. It has, however, been used in relation to the Diptera by Fallen, and other systematic authors.

Above the true wings, and a little behind them, are two small moveable bodies, almost membranous or slightly corneous, usually pale in colour, nearly linear in the greater part of their extent, but with a knob or button-like mass at the extremity, capable of dilatation. These are the balancers or *halteres*, of the nature and supposed uses of which we have already spoken at sufficient length in our general introductory observations.[2]

Above the balancers we find two membranous or papyraceous pieces, usually white or yellowish, ciliated, united together by one of their sides, and having the form of two valves of a shell applied upon each other. These are the winglets, or *ailerons* of the French writers.[3] Their size seems to be in an inverse proportion to the length of the balancers, which to a certain extent they cover and protect. One of them is attached to each of the corresponding wings, and participates in its movements,—but during flight the valves are held in separation, or nearly on the same plane.

The abdomen of dipterous insects is frequently attached to the thorax by a portion only of its transverse diameter. It is composed of from five to nine apparent segments, and in the females usually terminates in a point; in those, however, in which the segments are fewer, the terminal ones form a kind of ovipositor, presenting a succession of small tubes which slip into each other somewhat after the fashion of the different portions of a telescope. It results from this conformation that several of the hinder stigmata are by no means distinctly perceptible.

The legs are usually long and slender, and are terminated by five-articulate tarsi, with two hooks at the extremity, besides, in many instances, two or three small cushion-like expansions, either membranous or vesicular. It is by means of these last-mentioned parts, according to certain authors, that flies are enabled to creep up the smoothest perpendicular surfaces, or to walk on ceilings with their backs downwards.[1]

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[1] See Plate CCXX. fig. 7, *a*, *b*, *c*, *d*,—and the detailed description given at page 69, note 4.

[2] See page 75, note 2.

[3] We name them *wing-scales* in the ensuing portion of this treatise, from the German word *schuppschen*, used by Meigen.

Dr Derham had long ago observed that "diverse flies and other insects, besides their sharp-hook'd nails, have also skinny palms to their feet, to enable them to stick on glass and other smooth bodies, by means of the pressure of the atmosphere."[2] This opinion, very generally adopted by entomologists, derived additional weight from Sir Everard Home's papers on the subject, illustrated by drawings from the always admirable pen of Mr Bauer.[3] The structure of the parts, however, has been variously described by different authors, and by some in such a manner as (supposing their descriptions accurate) to render the organs unfit for the uses supposed, or at least for the particular mode of action assigned by Derham and Home, and coincided in by Messrs Kirby and Spence.[4] Thus Dr Hooke described the house-fly as having the soles of its feet beset underneath with small bristles or tenters, like the wire teeth of a card for working wool, and which he conceived to give them a strong hold upon any object having irregular or yielding surfaces. In regard to glass, which is neither yielding nor irregular, he imagined that it bore upon it a kind of smoky substance, penetrable by the points of the bristles.[5] The want of accordance in these accounts lately induced Mr Blackwall to inspect the parts minutely under a good compound microscope, when he immediately became convinced that the function assigned by the writers we have first named was incompatible with the actual organization. "Minute hairs," he observes, "very closely set, and directed downwards, so completely cover the inferior surface of the expanded membranes, improperly denominated suckers, with which the terminal joint of the tarsi of flies is provided, that it cannot be brought into contact with the objects on which those insects move, by any muscular force they are capable of exerting. The production of a vacuum between each membrane and the plane of position is therefore clearly impracticable, unless the numerous hairs on the under side of these organs individually perform the office of suckers; and there does not appear to be any thing in their mechanism which in the slightest degree countenances such a hypothesis."[6] Mr Blackwall then procured living specimens of the house-fly, *Musca domestica*, and of the large flesh-fly, *Musca vomitoria*, and enclosed them in clear jars and phials of transparent glass, the interior surface of which they traversed in every direction with the greatest facility, even walking upon it with their backs downward, while they remained in full vigour; but when enfeebled either by exposure to cold or by the fatigue of over exertion, the identical individuals ascended the sides of the same jars and phials with difficulty (falling from them frequently), and were altogether incapable of adhering in an inverted position. No sooner, however, were they recruited by repose or an increase of temperature, than they again repeated those extraordinary feats, to which custom makes us callous, with all their original dexterity. He likewise found, that flies which are unable to maintain an inverted position on highly polished bodies, will frequently adhere firmly, with their backs downward, to glass defective in polish or slightly soiled. This and other facts plainly indicated that flies are not supported on the vertical sides of smooth bodies either by the pressure of the atmosphere or by the aid of a glutinous secretion (as conjectured by some authors), but by means strictly mechanical, as suggested by Dr Hooke. It has been found, in fact, that the house-fly, while it retains its vital powers unimpaired, can not only traverse the upright sides, but even the interior of the dome of an exhausted receiver; and that the cause of its relaxing its hold, and ultimately falling from the station it occupies, is a diminution of muscular force attributable to impeded respiration.[7]

In regard to the anatomical structure of the dipterous order, the following is the substance of the observations on the subject given by M. Marcel de Serres, in his admirable memoir *Sur le Vaisseau dorsal des Insectes.* The dorsal vessel (now regarded as the heart) is itself narrow, and its pulsations frequent. The respiratory system consists of vesicular tracheæ, communicating with each other by tubular tracheæ, and unfurnished with those cartilaginous hoops which we find in the Orthoptera. The nervous system is generally composed of a small cerebriform ganglion with approximated lobes, from which proceed large optic nerves; two medullary cords of the ordinary kind (already described in our preceding general introduction) form from space to space about nine ganglia, of which three belong to the thorax and six to the abdomen. The intestinal tube presents, 1*st*, an œsophagus extending to the base of the abdomen; 2*d*, a rather elongated stomach, somewhat narrow, and furnished at its origin with a considerable number of hepatic vessels; 3*d*, a cylindrical duodenum, also accompanied by hepatic vessels, but of narrower dimensions; 4*th*, a short and muscular rectum.

All the Diptera dissected by M. Dufour were provided with salivary glands, a character which that accurate observer regards as being common to all insects furnished with a sucker. The structure, however, of those parts varies according to the genus.[8] They no doubt serve to increase the fluidity of the nutritive juices absorbed by the sucker. We may add, that both Dufour and Dutrochet have observed that the stomach of many Diptera is accompanied by a kind of paunch, in which a portion of the aliments is deposited.

Many tribes of this extensive order, if not decidedly noxious, at least occasion us great annoyance, not only by sucking our own blood, but by laying their eggs on the bodies of our living domestic animals, and on whatever uncooked fleshy viands they can attain to, especially during sultry weather, when the process of corruption is the most speedy, and the insects themselves are in their prime of strength and vigour. On the other hand, they may be regarded as serviceable, on account of the rapid consumption, by their most gluttonous larvæ, of all animal and several vegetable substances in a state of putridity. Their term of life in the perfect state is but of short duration. A few months or even weeks elapse, and their merry course is run. Such as contrive to fight their way to the conclusion of the ambiguous autumn, perish on the first approach of frost. A few half-benumbed house-flies indeed are generally seen in our apartments till Christmas time; and the delusive gleam of a sunny winter day not seldom re-animates their feeble forms so far as to produce a dubious buzz about our windows; but such as show themselves in open places are speedily snapped up by redbreasts and other feathered epicures, greedy of insect food at that unaccustomed season; and it is probable that few survive till spring. As their eggs, however, are generally deposited in a putrescent nidus, adapted to the propensities of the incipient young; and as that nidus is not of a nature to remain for a length of time unconsumed, it may be fairly inferred that our summer swarms are produced originally from a few individuals, which in some snug corner have survived the most inclement season of the year, and are not the result (as happens in the case of many lepidopterous kinds) of eggs which have been laid during the preceding autumn. It is possible that such as assume the pupa state towards the close of summer under ground, may rest secure in that condition, till called into their winged existence by the returning warmth of the enlivening spring.

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[1] *Phil. Trans.* 1816. An analogous structure, according to Sir Everard Home, enables the walrus to ascend the inclined plane of a slippery iceberg.

[2] *Physico-Theology*, p. 363, note 6.

[3] *Phil. Trans.* for 1816.

[4] *Introduc. to Ent.* vol. ii. letter xxiii.

[5] *Micrographia*, p. 170.

[6] *On the Pulvilli of Insects, Linn. Trans.* vol. xvi. part iii. p. 488.

[7] *Ibid.* p. 490.

[8] *Recherches Anatomiques sur l'Hippobosque des Chevaux, Annales des Sciences Nat.* vi. 301.

All these insects undergo a complete metamorphosis, and are remarkable in this, that the larvæ do not change their skins except at the period of their passing into the nympha state. Some form a kind of cocoon; but others remain uncovered, and can scarcely be even said to change their skin, which seems to harden over them, so as to form an egg-like case for the enclosed pupa. Dipterous larvæ are apodal or without feet, although some which belong to the family Nemocera of Lat. are provided with appendages which serve the same purpose. The head is sometimes projected and constant in its form, sometimes variable in figure, capable of being withdrawn into the body, and undistinguishable from the other segments except by its anterior position, and the existence of the parts of the mouth. This soft and changeable form of the head is, we conceive, peculiar to the larvæ of the present order. It is generally furnished with one or two retractile hooks, and some nipple-like projections. The principal orifices of respiration are almost always placed at the posterior extremity; and in many species there is also a pair of stigmatic openings on the segment next the head. Such as dwell in water, or inhabit corrupt and fluid matters, have their bodies terminated posteriorly by a tail-like prolongation, susceptible of being lengthened or withdrawn according to circumstances, and ending in a radiated expansion, which communicates with internal tracheæ. There are few pieces of natural mechanism so ingenious and admirable as the respiratory systems of the rat-tailed worm, and of the larvæ of gnats and other aquatic Diptera.

We have already alluded to the peculiar transformation of these insects. The skin of the larva seems to harden over and enclose the nymph. The body of the contained insect first detaches itself to a certain extent from the outer skin, leaving on its inner surface the exuviæ of its external organs. In its early state it presents only a soft or gelatinous mass, without distinct characters; but after a time the parts of the perfect insect begin to be developed, and it finally escapes from its prison by butting with its head against the upper part of the case, which ere long opens as it were upon a hinge, like the lid of a cylindrical snuff-box.

The general characteristics of this order are obvious to the eye of an ordinary observer, and are designated in the works even of the most ancient naturalists. Yet Fabricius, by placing with the Diptera certain Arachnides, and the parasitical species of the genus Pediculus, falsified the essential nature of the order. It cannot be denied, however, that here, as in all other great natural groups, there are anomalous or aberrant genera, which depart in a great measure from the ordinary conditions of their kind. Thus, among the pupiparous tribes, the wings, the balancers, and the usual sheath of the sucker, show a tendency to disappear in many species; and in *Nycteribia* and *Melophagus* the organs of flight are entirely wanting.[1]

DIVISION I.—PROBOSCIDEÆ.

The apex of the proboscis with a fleshy labium, and the haustellum covered by a horny labrum; before these are placed two jointed palpi.

A. The antennæ consisting of many joints.

FAMILY I.—TIPULARIÆ.

Antennæ extended forwards, consisting of six or more distinct joints. Palpi standing out, jointed. Halteres naked. Abdomen with seven or eight segments.

a. Culiciformes.

Eyes lunate: ocelli wanting: antennæ of the males plumose, of the females pubescent: mouth not elongate: palpi five-jointed: thorax without a cross suture: abdomen consisting of eight segments.

*

Proboscis extending forwards, longer than the antennæ; palpi straight; wings with the nervures and margin covered with scales.

Genus Culex, Linn. Antennæ porrect, or extending forwards, filiform, fourteen-jointed; plumose in the male, pilose in the female; palpi porrect, five-jointed, longer than the proboscis in the male, very short in the female; proboscis porrect, the length of the thorax: wings scaly, incumbent. Meig. *Zw.* pl. i. fig. 1–10.

The species of this and of some nearly allied genera are extremely troublesome towards evening, especially in the neighbourhood of moist or marshy places. They are greedy of blood, and under the well-known names of Gnats, Mosquitoes, &c. they persecute man and beast, not only sucking our "life-stream," but instilling a poison which, though feeble from its minute quantity, yet often produces pain and inflammation. Although abundant in Italy and all the warmer countries of the earth, they are nowhere more troublesome than amid the barren wastes of Lapland. They feed also on vegetable juices. The female deposits her eggs in the water to the amount of several hundreds, and the larvæ are consequently very frequent in all stagnant pools in spring and summer, where they may be seen when undisturbed, suspended from the surface, with their heads downwards. At this time they breathe by the caudal extremity; but in the nympha state, during which they are still aquatic, the respiratory organs are placed upon the thorax. On assuming the perfect state, the light exuviæ of the nymph serve as a support, by means of which the imago sustains itself for a time on the surface of the waters. The whole of these transformations are passed through in the course of three or four weeks. It is said that the females alone annoy us as blood-suckers. Their

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[1] The principal works on this order are, Fallen's *Diptera Suecica*, 4to, 1814–17; Meigen's *Systematische beschreibung der bekannten Europaischen Zweiflugeligen Insecten*, 8vo, 1818–1830 (by this work we are guided in the ensuing portion of our article); Wiedeman's *Diptera Exotica*, 8vo, 1821; and Macquart's *Insectes Diptères du Nord de la France*, 8vo, 1826–9, published in the *Mém. de la Soc. Royale*, &c. de Lille.

Diptera Proboscideæ.

shrill nocturnal pipe, the prelude to a closer contact, is particularly distressing in many continental countries, especially to an inexperienced traveller, unprovided with a *cousinière* or mosquito curtain. The Laplanders defend themselves by means of smoke and grease.

C. *pipiens.* Palpi and antennæ dark brown: thorax rufous, nearly rust colour, with two brown longitudinal lines: abdomen ringed with whitish grey and dark brown: halteres whitish: wings unspotted: legs pale brownish, the base of the thighs yellowish; the apex of the tibiæ with a small spot of changeable white. Length three lines. Fab. Linn. Réaumur. Wood's *Illus. of Linn. Genera of Insects*, pl. xcvii. Common in almost all countries.

Genus Anopheles, Meigen. Antennæ porrect, filiform, fourteen-jointed; plumose in the male, pilose in the female: palpi porrect, five-jointed, the length of the proboscis: proboscis porrect, the length of the thorax: wings scaly, incumbent. Meig. *Zw.* i. 10, pl. i. f. 11–17; Curtis, *Brit. Ent.* v. pl. ccx.

A. *bifurcatus.* Plume of the antennæ brownish grey in the males: the two terminal joints of the palpi forming a flat club; circle round the eyes white: thorax ash grey, with a dark-brown line on the sides, and three others down the middle: abdomen grey, ringed with brown: legs brown, the thighs yellowish: halteres dirty white; wings unspotted. The colour of the female is yellowish brown. Three and a half lines. Curtis, *l. c.* *Culex bifurcatus*, Linn. According to Linnæus, the larva, like those of the preceding genus, reside in the water, and the perfect insect does not bite. Only one other species is described by Meigen, which is distinguished by having five dusky spots on each wing. Two others are described in the third volume of the *Zoological Journal.*

Genus Ædes, Hoffmgg. Antennæ porrect, filiform, fourteen-jointed; plumose in the male, pilose in the female: proboscis porrect, as long as the thorax: palpi very short: wings scaly, incumbent. Meig. *Zw.* i. 13.

Æ. *cinereus.* Greyish brown: thorax reddish, pubescent: wings unspotted: thighs rather paler than the other parts of the leg: palpi very short, in other respects not differing much from Culex. Two to two and a half lines. Apparently a rare and imperfectly known insect.

* *

Proboscis shorter than the antennæ; palpi incurved.

Genus Corethra, Meig. Named from the Greek word *κόϱηθϱον, a brush*, with reference to the appearance of the antennæ. Antennæ porrect, filiform, fourteen-jointed; verticillately plumose in the male, pilose in the female: palpi standing out, incurved, four-jointed, the first joint shortest: wings incumbent, the nervures villose, and the hinder margin ciliated with scales. Meig. *Zw.* i. 14, pl. i. f. 18–23.

C. *pallida.* Whitish: plume of the antennæ brown; eyes black: thorax with three pale-brown abbreviated lines: thighs and tibiæ white, spotted with black; the joints of the tarsi somewhat brownish: wings hyaline, with an obsolete brownish shade over the middle. Male two and a half, female two lines. Meig. *Zw.* vol. i. pl. i. fig. 23, *female.* Found on the continent of Europe. *C. plumicornis* and *culiciformis* inhabit Britain, and have been described, with their usual felicity, by Réaumur and Degeer. Their larvæ differ from those of Culex in their usually horizontal posture. That of *C. plumicornis* is remarkable for its translucent texture, which renders it almost invisible. It was hence called *Tipula cristallina* by Degeer.

Genus Chironomus, Meig. (Plate CCXXXVIII. fig. 1). Antennæ porrect, filiform, in the male plumose, thirteen-jointed; the terminal joint very long (ibid. fig. 1, *a*); in the female six-jointed, pilose; palpi standing out, incurved, four-jointed; wings lanceolate, deflexed. Meig. *Zw.* i. 18, pl. ii. f. 1–7.

C. *elegans.* Head light yellow; plume of the male antennæ brown; female antennæ pale yellow, the terminal joint brown; thorax hood-shaped in front, elongate, sulphur-yellow, with fulvous vittæ, and having three black spots on each side in the form of a triangle, towards the base of the wings; abdomen sulphur-yellow; legs fulvous, thick, with black joints and a ring of the same colour in the centre of the middle and hinder tibiæ; anterior tarsi not elongate; wings white, with three black points not far from the hinder margin, one towards the middle, and two others near each other, towards the apex. Three to three and a half lines. Meig. *Zw.* vol. i. pl. ii. f. 7, *female.* This rare species, represented by the figures last referred to, has been taken lately at Raehills in Dumfriesshire. We believe it to have been previously unknown in Britain. The genus is very extensive, comprehending little short of a hundred species, the greater portion of which inhabit Britain. The little pink-coloured tortuous worm, frequent in water-barrels, is the larva of *Chironomus plumosus.*

Genus Tanypus, Meig.; named from *τανυω, to stretch out*, and *πους, the foot.* Antennæ porrect, filiform, fourteen-jointed; in the male plumose, with the twelve lowest joints globose, the thirteenth very long, the terminal short and acute; in the female pilose, all the joints globose, the terminal thickest; palpi standing out, incurved, four-jointed, the basal joint shortest; ocelli wanting; wings lanceolate, deflexed, pilose. Meig. *Zw.* i. 55, pl. ii. f. 8–12.

T. *varius.* Male. Antennæ and palpi brown; head and thorax grey, the lines on the latter dark brown, with a grey play of colour in the middle; abdomen yellowish, banded with brown, and having a blackish line on the back; legs brownish yellow, the knee and apex of the tibiæ brown; halteres white; wings with an oblique grey cloud before the apex, having two dark-brown spots in it near the anterior border, and three smaller dark spots at the hinder margin; there is a grey spot at the apex of the wing, and near the middle a rather broad band, in the anterior part of which are placed three blackish spots, two behind each other, and the third, which is smaller, beneath, forming a triangle. The female is of a yellower hue than the male, and the marks on the back, as well as the bands on the abdomen, are paler; the wings are marked in a similar manner. Male three to three and a half, female two to two and a half lines. Meig. *Zw.* i. pl. ii. fig. 12, *male.* Frequents banks and hedges, but is not common. It occurs near London, and in some other parts of England.

The *Tipula maculata*, of which the history is given by Degeer, belongs to this genus. Twelve species are described by Benoit Frederick Fries, in his *Monograph* of the Swedish Tanypi. His work is enriched by some new historical details. Above twenty species occur in Britain.

Genus Ceratopogon, Meig. The generic name is derived from *κεϱας, a horn*, and *πωγον, a beard.* Antennæ porrect, filiform, thirteen-jointed, the eight lowest joints globose (bearded externally in the male), the following cylindrical, elongate; palpi porrect, incurved, four-jointed, the joints unequal; ocelli wanting; wings parallel, incumbent. Meig. *Zw.* i. 68, pl. ii. f. 13–18.

The larvæ of these insects differ from those of most of their congeners in not being aquatic. They inhabit vegetable galls. The species are numerous, and of small dimensions. Meigen describes forty-five different kinds, of which about one half have been detected in Britain.

C. *bipunctatus.* Black; the antennæ, including the brush of the males, dark brown; thorax clothed with fine yellow pubescence; halteres white; wings thickly covered

Diptera Proboscideæ.

with grey pubescence, and having a whitish spot in the middle of the anterior margin; legs pitch-brown; tibiæ with long hairs externally; pubescence of the tarsi white. One line. *Tipula bipunctata*, Linn.; *Forcipomyia pictipennis*, Megerle; *Labidomyia bipunctata*, Stephens. Inhabits England and various parts of the continent.

GENUS MACROPEZA, Meig. So named from *μακρος*, *long*, and *πεζα*, *the foot*, the hinder legs being remarkable for their length. Antennæ porrect, filiform, fourteen-jointed; the joints cylindric, the five last longest: wings lanceolate, elongate; hinder legs very long. Meig. *Zw.* i. 87, pl. iii. f. 1, 2.

M. *albitarsis*. Head black, with a broad forehead without ocelli; thorax cinereous, with three narrow black lines, the central one widest; sides of the thorax and shoulders black; scutellum cinereous; abdomen black; halteres white; wings hyaline, with pale-brown nervures; legs black, the tarsi whitish; the hinder legs uncommonly long, particularly the tarsi, which are as long as the thighs and tibiæ united. Length one and a third. Length of the wing two and two thirds, of the hinder legs four lines. Pl. iii. f. 1, *female*. The female only of this singular insect appears to be known: it has not occurred in Britain.

b. Gallicolæ.

Eyes lunate: antennæ with hairs disposed in whirls; palpi incurved; wings pubescent, obtuse, with two or three longitudinal nervures; tibiæ without spurs at the end.

GENUS LASIOPTERA, Meig. The name is from *λασιος*, *hirsute*, and *πτερα*, *wings*. Antennæ porrect, filiform, consisting of many joints, which are globose and hairy; ocelli wanting: wings incumbent, villose, with two nervures. Meig. *Zw.* i. 88, pl. iii. f. 3–5.

L. *picta*. Female. Antennæ black, shorter than the thorax, cylindrical, twenty-four jointed; the joints nearly globose and pubescent: thorax black; abdomen black, margined with white, and having two triangular white spots on each segment: thighs yellow; tibiæ and tarsal joints white, with the apex black: halteres white: wings ash-grey, having a narrow black edge anteriorly, in which there is a white spot. One line. Meig. *Zw.* i. pl. iii. fig. 3, *female*. *Diomyza Juniperi*, Megerle.

Occurs on the continent of Europe, but is rare.

GENUS CECIDOMYIA, Latreille. Antennæ projecting, moniliform, many jointed, the joints remote from each other: ocelli wanting; first joint of the tarsi very short: wings incumbent, villose, with three nervures. Meig. *Zw.* i. 93, pl. iii. fig. 8–12.

C. *palustris*. Thorax pale, with three broad black vittæ: abdomen flesh-red; the halteres white. *Tipula palustris*, Fab. Linn. Not unfrequent in Britain and elsewhere. We have nearly thirty indigenous species, among which *C. tritici*, commonly called the *wheat-fly*, is an object of great interest to the agriculturist.[1]

GENUS CAMPYLOMYZA, Wied. Antennæ projecting, cylindrical, fourteen-jointed, the two radical joints thickened: ocelli three: wings pilose, with three nervures. Meig. *Zw.* i. pl. iii. fig. 6–7.

C. *bicolor*. Female. Antennæ dark brown: head and thorax black, somewhat shining: abdomen dark brown, with pale incisures: halteres white: legs testaceous: wings hyaline. Half a line in length.

Found in April and May in hedges, not common.

c. Noctuæformes.

Eyes lunate: ocelli wanting: antennæ moniliform, with a seta at the base: wings broad, villose, with numerous longitudinal nervures, but without cross nerves: tibiæ without spurs.

GENUS PSYCHODA, Lat. (Plate CCXXXVIII. figs. 2 and 2 *a*). Antennæ projecting, moniliform, pilose, many jointed, the two radical joints thick, the remainder globose, and remote from each other: palpi standing out, four jointed, the joints equal: ocelli wanting: wings broad, lanceolate, villose, without transverse nerves. Meig. *Zw.* i. pl. iii. fig. 13–18.

P. *palustris*. Head, thorax, and abdomen covered with white wool-like hairs: wings black at the apex, the centre with a dark-brown band, which forms an acute angle in the middle, the base shaded with brown; fringe dark brown, white at the apex of the wing: halteres dark brown: legs white; apex of the tibiæ and the two last tarsal joints black. Two lines. Meig. *Zw.* i. pl. iii. fig. 18. Found in Britain occasionally, along with above a dozen other species. We know little of the habits or metamorphoses of these insects. They occur in moist and impure, as well as in marshy places.

d. Rostratæ.

Eyes somewhat rounded, separated on the forehead; ocelli wanting: head elongated into a rostrum anteriorly: palpi incurved: thorax with an arched suture across the middle: abdomen eight-ringed: tibiæ more or less spurred.

GENUS ERIOPTERA, Meig. From *ειρος*, *wool*, and *πτερα*, *wings*. Antennæ projecting, setiform, sixteen-jointed, the first joint cylindrical, second cup-shaped, the following ovate: ocelli wanting: palpi standing out, incurved, cylindrical, four-jointed, the joints equal: intermediate legs shorter than the others: wings incumbent, parallel, the nervures villose.

E. *maculata*. Dirty yellow, as well as the antennæ and legs: thighs brown at the apex, and having a brown ring in the middle: palpi brown; the abdomen with a brown line along the back: wings with pale nerves and ferruginous ocellated spots, which are partly single and partly form a macular band. Two and a half lines. Inhabits Britain and the continent of Europe. We have about thirty ascertained indigenous species.[2]

GENUS LIMNOBIA, Meig. From *λιμνη*, *a marsh*, and *βιοω*, *I live*. Antennæ projecting, setiform, the joints from fifteen to seventeen, the radical joint cylindrical, second cup-shaped, the remainder oblong or globose: palpi standing out, incurved, cylindrical, four-jointed, the joints equal: ocelli wanting: wings generally incumbent and parallel, the nervures naked. Meig. *Zw.* i. pl. iv. v. vi.

L. *rivosa*. Antennæ as long as the head, setiform, reddish brown; palpi of a similar colour: head grey; the forehead with a small protuberance behind the antennæ: thorax light grey, with reddish-brown vittæ; scutellum yellowish; metathorax bright grey: abdomen light grey inclining to red, with a reddish-brown line on the back, which is waved on the sides, and has a grey play of colour in the middle: legs rather thick, testaceous, the thighs darker: halteres yellow: wings clear hyaline, having a testaceous streak along the anterior margin; not far from the base another streak leaves the marginal one and runs along the third longitudinal nerve, and from this a third runs along the cross nerves, forming an obtuse angle; the anterior streak has a semicircular projection near the middle, and just behind the base there is a transparent marginal streak with a black spot. From twelve to thirteen lines. *Tipula rivosa*, Linn.; *Tipula triangularis*, Degeer; *Pedicia rivosa*, Lat.

Rare on the continent. In Scotland we lately observed it in considerable numbers in several of the northern counties, frequenting marshy glades by the sides of rivers. It likewise occurs in the vicinity of Edinburgh. The genus Limnobia is rather extensive, containing upwards of sixty European species, the greater proportion of which are indigenous to Britain. Degeer has published some curious details regarding the manners and metamorphoses of *L. replicata.*[1]

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[1] See *Linn. Trans.* iv. 230, and v. 106.

[2] The genus is named *Eriopteryx* by Mr Stephens—a commendable change, in as much as it avoids a termination characteristic of the *ordinal* rather than the *generic* groups of Entomology.

Genus Rhipidia, Meig. Antennæ projecting, fourteen-jointed, the radical joint cylindrical, second and third cup-shaped, the following globose, remote, pectinated on two sides in the male: palpi standing out, incurved, cylindrical, four-jointed, the joints nearly equal: ocelli wanting: wings incumbent, parallel. Meig. *Zw.* i. pl. v. fig. 9–11.

R. *maculata.* Forehead light grey; palpi and antennæ brown, the latter twice the length of the head: thorax bright grey, with a brown vitta, which has an indistinct brown line close to it on each side behind: abdomen dark brown: halteres pale yellow: legs long, thin, brownish yellow; the apex of the thighs, the tibiæ, and the tarsi, brown: wings hyaline, the surface sprinkled with pale brown spots, some of which at the anterior border are larger and darker, and the cross nerve is margined with brown. Three lines. Meig. *Zw.* i. pl. v. fig. 11, *male.* Inhabits England, Germany, &c.

Genus Ctenophora, Meig. Antennæ projecting, thirteen-jointed, the radical joint cylindrical, second globose, third oblong, the following pectinated in the male, in the female simple, globose or ovate: palpi standing out, incurved, cylindrical, four-jointed, the terminal joint elongate: ocelli wanting: wings spreading, shining.

C. *bimaculata.* Head black: palpi rufous beneath, brown above: antennæ dark brown, the joints globular in the female: thorax and abdomen black; the latter in the female marbled on the sides and belly with rufous, which sometimes runs into orange-yellow, spots; the abdomen of both sexes has a greyish transverse spot at the base: halteres and legs rufous; the apex of the thighs, the tibiæ, and the tarsi dark brown: wings hyaline, the anterior margin yellow, having a dark-brown band, extending half way across, and the apex of the same colour. Male six, female from seven to eight lines. *Tipula bimaculata*, Linn. Found in Britain, with six other species belonging to the same genus.

Genus Tipula, Linn. (Plate CCXXXVIII. figs. 3 and 3 *a.*) Antennæ projecting, thirteen-jointed, the radical joint cylindrical, second cup-shaped, the following cylindrical and pilose: palpi standing out, incurved, cylindrical, four-jointed,[2] the terminal joint elongate: ocelli wanting: wings lanceolate, spreading.

T. *oleracea.* Palpi and antennæ dark brown, the two lowest joints of the latter yellowish grey; forehead bright grey, with a reddish-brown line; the snout yellowish brown: thorax bright grey, having a testaceous dorsal line bounded with dusky; metathorax whitish grey: abdomen testaceous, with a dusky line on the back, which is scarcely perceptible; thighs and tibiæ testaceous, the apex and the tarsi dark brown: halteres brown: wings pale brown, the anterior margin bordered with testaceous, but not to the apex; behind this border there is a whitish streak. Eleven lines. Linn. Fab. Degeer, Lat. This species is common in meadows. It is known in England by the title of *Harry Long-legs*, and is called *Jenny Nettles* in Scotland. The genus Tipula, considered in relation to Europe, contains forty-four species, several of which are large and conspicuous insects, and many of them are very plentiful. *T. crocata*, of a deep velvet black with yellow bands, is a very ornamental species. We have taken it near Edinburgh.

Genus Nephrotoma, Meig. Antennæ projecting, in the male nineteen-jointed, with the first and third joints cylindrical, second cup-shaped, the following excised; in the female fifteen-jointed, the first and third joints cylindrical, second cup-shaped, the following somewhat cylindrical, thickened at the base: palpi standing out, incurved, four jointed, the terminal joints elongate: ocelli wanting: wings lanceolate, spreading. Meig. i. pl. v. f. 19–22.

N. *dorsalis.* Antennæ with the first and second joints ferruginous, the rest black: ground-colour reddish yellow; the forehead with a black vitta: thorax with three shining black lines; the sides of the breast unspotted: scutellum with a black spot; metathorax marked with a black line, and the hinder margin of the same colour: abdomen with a black dorsal line, and a longitudinal line of the same colour on the sides and belly: thighs and tibiæ ferruginous, the apex brown: tarsi dark brown: halteres yellow: wings nearly hyaline, slightly clouded with brownish yellow, the stigma dark brown: the apex of the wing is likewise brownish. Male five and a half, female seven lines. Found in hedges during summer, but is not common. It has occurred in the vicinity of London.

Genus Ptychoptera, Meig. Antennæ projecting, sixteen-jointed, the radical joint short and cylindrical, second cup-shaped, third long and cylindrical, the following oblong: palpi standing out, incurved, elongate, four-jointed, the first joint shortest, second and third long, and of equal length, the fourth very long, setaceous: ocelli wanting: wings spreading, plicate at the hinder margin.

P. *contaminata.* The prevailing colour is shining black: palpi ferruginous: antennæ dark brown: the sides of the breast silky grey: scutellum testaceous: abdomen of the male with two ferruginous bands, that of the female with two ferruginous spots on both sides: legs rufous: the apex of the thighs, the tibiæ, and the tarsi, dark brown: halteres rufous, the knob brownish at the tip: wings nearly hyaline; near the middle of the anterior border is a dark-brown abbreviated band; between this and the apex there is a brown marginal spot, and two or three others at the anterior margin. Male three and a half, female five lines. *Tipula contaminata*, Linn. Fab. Lat. Not rare during summer in Britain and other parts of Europe.

Genus Nematocera, Meig. Antennæ projecting, filiform, six-jointed, the radical joints cylindric, second cup-shaped, the following cylindrical, equal: ocelli wanting: palpi standing out, incurved, four-jointed, the joints equal.

N. *bicolor.* Head ash-grey; forehead wide, brighter at the eyes: thorax bright grey, with three dark lines on the back, that next the side short: abdomen flat, dark brown: legs of the same colour, the base of the thighs, and likewise the halteres, yellow: wings rather dull, without a stigma. Five lines. Meig. *Zw.* i. pl. vi. fig. 1.

Seemingly rare: we are unacquainted with its native country. The specimens from which Meigen took his description were preserved in the collection of M. Baumhauer.

Genus Anisomera, Hoff. Antennæ projecting, setaceous, six-jointed, the radical joint cylindrical, second cup-shaped, third very long: ocelli wanting.

A. *obscura.* Antennæ brown: the prevailing colour of the body brownish grey; thorax with three wide dark

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[1] *Memoires*, t. vi. plate 20.

[2] Latreille says, "de cinq articles,"—but he counts the radical tubercle, which does not seem to have been regarded in Meigen's enumeration.

lines: along the abdomen of the males, which is nearly hoary, runs a narrow vitta, and on the under side of the first segment there is a broad yellow spot, and a smaller one on the second; wings brownish yellow, especially at the cross nerves; legs yellowish brown; the apex of the thighs dark; the anterior thighs thicker and shorter than the others. Four lines. Meig. *Zw.* i. pl. vii. fig. 5, *male.* Found in Germany, Portugal, and England. In the latter country another species has occurred, which has been named *A. lucidipennis.*

Genus Trichocera, Meig.; from τριξ, *hair*, and κερας, *a horn.* Antennæ projecting, setiform, the two lower joints thickened, the remainder oblong and pubescent; palpi standing out, incurved, cylindrical, five-jointed, the joints nearly equal: wings incumbent.

T. *hiemalis.* Palpi, antennæ, and legs, dark brown: head grey: thorax greyish, with four distinct brown vittæ, the hinder part unspotted: abdomen wholly dark brown passing into grey; the caudal process in the female shining black: halteres pale yellow, with a brown knob: wings pale grey or somewhat brownish, unspotted. Two and a half lines. *Limonia hiemalis,* Lat. Abundant in October and November, and usually found throughout the winter. Another British species, *T. regelationis,* is also often seen on walls and houses, even during that inclement season.

e. Fungicolæ.

Eyes round or oblong, separated on the forehead: ocelli unequal, sometimes wanting. Palpi incurved, four-jointed: thorax without a cross suture: abdomen seven-ringed: coxæ long: tibiæ spurred.

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Antennæ setiform, with indistinct joints, the two lower ones thickened.

Genus Dixa, Meig. Antennæ projecting, setiform, the two lowest joints thickened, the rest pubescent: palpi standing out, incurved, cylindrical, four-jointed, the first joint very short: ocelli wanting: wings incumbent, parallel.

D. *aprilina.* Palpi and antennæ dark brown: head brownish yellow, with a large blackish heart-shaped spot on the forehead: thorax light yellow, passing into brown, and marked with three dark lines: abdomen dark brown: halteres yellowish, with a brown knob: legs brownish yellow; apex of the thighs, of the tibiæ, and the tarsi, dark brown: wings hyaline, somewhat whitish, with brown nerves. Two lines. Meig. *Zw.* i. pl. vii. fig. 12, *male.* Found on the continent and in Britain. Meigen describes four species, two of which occur in this country, which also produces a third, named *D. variegata* by Mr Stephens.

Genus Bolitophila, Hoff. Antennæ long, setiform, projecting forwards, the two radical joints thick: ocelli three, placed on the forehead in a transverse line: wings incumbent, parallel, obtuse.

B. *fusca.* Head yellowish, with dark-brown antennæ: thorax yellowish, with three brownish lines on the back: abdomen, halteres, and legs, dark brown; basal half of the thighs yellow, which gradually passes into brown: wings somewhat greyish, with a brown spot at the stigma. Two to two and a half lines. English examples of this species are preserved in the British Museum. According to Mr Curtis, two other kinds inhabit Britain; viz. *B. maculipennis* and *B. cinerea;* the former of these does not appear to be known to continental naturalists. M. Guerin has published a complete and detailed history of a species of this genus, of which the larva lives in mushrooms.[1]

Genus Macrocera, Meig.; named from μακρος, *large,* and κερας, *a horn*—the antennæ being of unusual length. Antennæ projecting, setiform, long, the two radical joints thick: ocelli three, placed on the forehead in the form of a triangle: wings obtuse, incumbent, parallel.

M. *lutea.* Of a uniform ochre-yellow: antennæ above twice the length of the body, brown, yellow at the base: abdomen inclining to brown behind: legs yellow, with brown tarsi. Three lines. This species occurs in the south of England, and eight others are recorded as indigenous to Britain.

* *

Antennæ compressed, sixteen-jointed.

Genus Synapha, Meig. Antennæ projecting, cylindrical, sixteen-jointed? the two lowest joints distinct: eyes rounded: ocelli three, unequal, placed in a line on the forehead: tibiæ unarmed on the sides.

S. *fasciata.* Head and antennæ black: palpi ferruginous: thorax pubescent, shining black; scutellum of a similar colour, small: first four joints of the abdomen shining red, with a black band across their hinder margin, the remainder black: thighs and tibiæ ferruginous, tarsi brown: wings hyaline, the central longitudinal nerve forming an oblong cell behind the cross nerve. One and a half line. Inhabits Germany, but is rare.

Genus Mycetobia, Meig. Antennæ projecting, cylindrical, sixteen-jointed, the two radical joints distinct: eyes kidney-shaped: ocelli three, unequal, approximating, placed on the forehead in the form of a triangle: tibiæ unarmed on the sides.

M. *pullipes.* Black: palpi yellow: antennæ brown, nearly cylindrical, and about the length of the thorax; the latter somewhat pubescent: abdomen rather depressed: halteres and legs bright yellow, the tarsi passing into brown at the apex: wings large, rounded at the apex: and having brownish-black nervures. One and a half line. Occurs in the vicinity of London, and in some other parts of Britain.

Genus Platyura, Meig. Name derived from πλατυς, *broad,* and ουρα, *the tail.* Antennæ projecting, compressed, sixteen-jointed, the two radical joints distinct: eyes rounded: ocelli three, approximating, unequal, placed on the forehead in the form of a triangle: tibiæ unarmed on the sides: abdomen depressed behind.

P. *semirufa.* Head, antennæ, and thorax black; the latter with a narrow arched line of white anteriorly: abdomen yellowish red, passing into brown, the two first segments black: halteres and legs rufous, the tarsi brown: wings nearly hyaline, without spots or bands. Three lines. Found near London, Edinburgh, and in the border counties of Scotland Thirteen other species are natives of Britain.

Genus Gnoriste, Hoff. Antennæ projecting, cylindrical, sixteen-jointed, the two radical joints thick and short: proboscis elongate, bearing the palpi at the apex: ocelli three, unequal, placed on the forehead in the form of a triangle: tibiæ spurred at the apex, the sides spinose.

G. *apicalis.* Head black; antennæ dark brown: proboscis twice the length of the head; the palpi, which are inserted near the apex, small and ferruginous: thorax black, impressed with two deep longitudinal lines, which become obsolete behind the middle: abdomen dark brown, pubescent: halteres yellow: coxæ elongate, the anterior pair ferruginous, the others black: thighs and tibiæ yellow, the tarsi dark brown: wings somewhat clouded, the apex brown. Five lines. Has been found in Prussia, but is rare.

Genus Sciophila, Hoff. Antennæ projecting, somewhat compressed, sixteen-jointed, the two radical joints distinct: ocelli three, unequal, approximating, placed on the forehead in the form of a triangle: tibiæ with spurs at the apex, and spines on the sides: wings with the intermediate cell small and nearly quadrate.

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[1] *Annales des Sciences Nat.* t. x.

S. *fimbriata.* Ferruginous; antennæ brown, yellow at the base; anterior part of the head yellow, the forehead brown: thighs ferruginous, tibiæ and tarsi brown: abdomen pubescent, the segments margined behind with black, the hinder extremity likewise black: wings unspotted, hyaline. One two-thirds. This insect, and seven other species of the genus, occur in Britain.

Genus Leia, Meig.; named from λειος, *smooth.* Antennæ projecting, compressed, sixteen-jointed, the two radical joints distinct: eyes oblong: ocelli three, unequal: tibiæ with spurs at the apex, the hinder ones spinous on the sides.

L. *flavicornis.* Ochraceous, as well as the antennæ: ocelli remote: thorax and abdomen somewhat shining: tarsi brown: wings slightly yellowish, with a narrow, somewhat arched, cross band of brown before the apex, slightly increasing in width at the anterior border; and towards the hinder margin of the wing there is a small pale-brown spot placed at the hindermost longitudinal nerve. Two lines. Meig. *Zw.* i. pl. ix. fig. 11, *female.* Inhabits Britain, with four others of the ten described by Meigen as occurring in Europe.

Genus Mycetophila, Meig. Antennæ projecting, compressed, sixteen-jointed, the two radical joints distinct: eyes oblong: ocelli indistinct: tibiæ with spurs at the apex, the hinder ones with spines on the sides.

M. *lineola.* Hypostoma[1] and palpi yellow; antennæ greyish brown, the two radical joints yellow: thorax ochreous above, with three brown lines, the sides of the breast with a mixture of grey: abdomen brown, with yellow incisures: halteres yellow: legs pale yellow, the tarsi brown; hinder thighs black at the apex: wings yellowish, somewhat dusky along the anterior border, and marked with a dark-brown spot near the middle. Two lines. Meig. *Zw.* i. pl. ix. fig. 15. This species occurs in Roxburghshire, near London, and on the continent of Europe. The genus contains thirty species; of these upwards of twenty are included in the entomological catalogues of Britain. The larvæ of several species are found in great numbers in fungi, on the substance of which they feed. The *M. fusca* of Lat. and Meigen seems indeed to have been described by Degeer under the name of *Tipula fungorum.*[2]

Genus Cordyla, Meig. Antennæ projecting, twelve-jointed, the two radical joints distinct: eyes rounded; ocelli wanting: tibiæ with spurs at the apex, but unarmed on the sides.

C. *crassicornis.* Head blackish; antennæ twice the length of the head, compressed when seen from the side, the colour dark brown: thorax grey, the back darker in the middle: abdomen dark brown: halteres and legs bright yellow, the hinder thighs brown at the apex; tarsi brown: wings grey. One and a half. Meig. *Zw.* i. pl. x. fig. 1. Inhabits Austria, England, &c.

f. Lugubri.

Eyes nearly meeting above, and deeply margined: ocelli unequal: antennæ cylindrical: palpi three-jointed: thorax without cross suture: abdomen seven-ringed.

Genus Sciara, Meig. Antennæ porrect, cylindric, pubescent, sixteen-jointed; the two basal joints thickest: eyes deeply emarginate: ocelli unequal: palpi exserted, incurved, three-jointed: wings incumbent, parallel.

S. *Thomæ.* Black; abdomen with a longitudinal line of saffron yellow on each side, consisting of spots in the male, and narrower than in the female; the last has the incisures also yellow: wings smoke coloured, iridescent: halteres and legs piceous: thighs of the fore legs rufescent in both sexes. Four lines. *Tipula Thomæ,* Linn.; *Molobrus Thomæ,* Lat. Occurs at times in tolerable plenty in woods in the south of Scotland, and in many parts of England, generally frequenting umbelliferous plants, in the months of June, July, and August.

g. Latipennes.

Eyes of the male meeting above, those of the female separated and kidney-shaped; ocelli wanting: antennæ cylindrical: palpi four-jointed: proboscis porrect, perpendicular: abdomen eight-ringed: wings very broad.

Genus Simulia, Meig. Antennæ porrect, cylindric, eleven-jointed, the two basal joints distinct: palpi exserted, incurved, cylindric, four-jointed, the basal joint shortest: ocelli wanting: wings broad, incumbent, parallel.

S. *reptans.* Female. Palpi and antennæ brown; hypostoma white; forehead blackish blue; thorax brown, with a bluish play of colour, the anterior part cinereous, with a brown line in the middle, which has a cross streak of brown close to it on each side; the hinder part with an ash-grey play of colour: abdomen dark brown, with pale-yellow hairs at the base, the hinder segment shining bluish grey: thighs brown: tibiæ white, brown at the apex: anterior tarsi deep black, the medial and posterior tarsi brown: halteres pale yellow. One line. *Culex reptans,* Linn.; *Simulium reptans,* Lat. Of pretty frequent occurrence in Britain, and other countries. We have above a dozen indigenous species. These insects bite sharply, and attack various animals.

h. Muscæformes.

Eyes of the male meeting above, in the female separate and round: ocelli three, of equal size: antennæ cylindrical: thorax without a cross suture in the middle.

Genus Scatopse, Geoff. Antennæ projecting, cylindrical, perfoliate, eleven-jointed: eyes kidney-shaped: ocelli three: palpi concealed: legs unarmed.

S. *notata.* Shining black, smooth. The thorax has a white spot on the sides anteriorly: and there is another, crescent-shaped, before the base of the wing, and a similar crescent-shaped spot is placed on the sides at the base of the abdomen: halteres black. One and a third line. *Tipula notata,* Linn.; *Tip. latrinarum,* Degeer, vi. 160, pl. xxviii. p. 1–4; *Tipula albipennis,* Fab. Found in England, Scotland, Germany, &c.

The palpi in the preceding genus, as far as perceptible, seem to consist of only a single articulation—a character in which they differ from their congeners. The larvæ are apodal, and live in impure substances. The nymphs are naked and motionless. The perfect insects occur on the trunks of trees, on moist walls, and on flowers, especially those of the *Synantheræ,* of which they suck the nectaries. The species are few in number, and of small size.

Genus Penthetria, Meig. Antennæ projecting, cylindrical, perfoliate, eleven-jointed: eyes oval: ocelli three: palpi standing out, incurved, four jointed: legs unarmed.

P. *holosericea.* Entirely velvet-black, with brown eyes and wings: forehead of the males very narrow, that of the female wide; head in both sexes as wide as the thorax: wings of the male much smaller than those of the female: legs pubescent, without spines, much longer in the male than in the female. Male two and a half, female three and a half lines. Lat. *Gen. Crust.* iv. 267; Meig. *Zw.* i. pl. x. fig. 17, 18. Found in Germany, &c.

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[1] This term is used by Meigen to designate the region of the head lying between the antennæ, the eyes, and the mouth. The same part is named *clypeus* by Fallen.

[2] *Mémoires,* t. vi. pl. 22. fig. 1–13.

Genus Dilophus, Meig.; from δις, *two*, and λοφος, *a comb*. Antennæ projecting, cylindrical, perfoliate, eleven-jointed: palpi standing out, incurved, five-jointed, the third joint dilated at the apex: anterior tibiæ radiated at the apex.

D. *vulgaris*. Shining black: wings of the males hyaline, with blackish marginal nerves; those of the female brown, with the apex hyaline, the nerves with a pale margin, and the stigma blackish. Two and a half lines. Meig. *Zw.* i. pl. xi. fig. 1, *male*. *Tipula febrilis*, Linn. Fab. Lat. Common during spring and summer.

Genus Bibio, Geoff. Antennæ projecting, cylindrical, perfoliate, nine-jointed; palpi incurved, cylindrical, five-jointed, first joint very short: ocelli three: anterior tibiæ mucronate at the apex. Meig. i. 309, pl. xi. f. 9–15; Curtis, *B. E.* pl. cxxxviii.

B. *Pomonæ*. Shining black, with pubescence of the same colour: thighs rufous: wings hyaline, the anterior margin fuscescent, marginal nervures and stigma dark brown. Male six, female seven lines. *Tipula Pomonæ*, Fab. Don. ix. 27, pl. ccc.

B. *Marci*. Very like the last, but entirely black; wings of the males hyaline, of the females brown; both have the anterior margin dark brown, with black-brown nervures, and a stigma of the same colour. Five to six lines. ♀ *Tipuli Marci*, Linn.; *Hirtea Marci*, Fab.; ♂ *Tip. brevicornis*, Linn. These two species, which are the largest of the genus, occur not unfrequently in Britain: in the south of Scotland the former is common, and we have often seen large *flocks* of the latter near Edinburgh.

In this genus the sexes differ considerably, which has not seldom led to the males and females being described as distinct species.[1] The larvæ are frequently found in the dung of cattle. They are apodal, but otherwise bear a resemblance to small caterpillars, being furnished with a few hairs directed backwards. They are also believed to change their skins before assuming the nympha state. The perfect insects appear in spring; and, according to the continental naturalists, at two different periods, corresponding to the feasts of St Mark and St John,—a circumstance which has obtained for them the names of *Mouches de St Marc* and *Mouches de St Jean*. Their flight is heavy, and they are sometimes seen in great quantities on fruit trees, to which, however, notwithstanding a vulgar prejudice to the contrary, they are in no way injurious. Meigen describes sixteen European species, and Mr Stephens enumerates fourteen as occurring in Britain. Their manners are curiously detailed by Réaumur.

Genus Aspistes, Hoff. Antennæ projecting, eight-jointed, the terminal joint thickened, ovate: ocelli three: anterior tibiæ terminating in a spine.

A. *berolinensis*. Antennæ black, somewhat longer than the thorax, the two lowest joints thickened at the apex, the following short, the terminal one broader, ovate, and excavated in the middle: thorax pitch-black, with an oval spot on the back anteriorly: abdomen pitch-black, pubescent, the hinder extremity brownish red: thighs nearly black; tibiæ and tarsi reddish yellow: wings hyaline, the marginal nervures dark brown, the others pale brown: halteres black. One line. Inhabits Germany, Prussia, &c. One or two other species are said to occur in Britain.

Genus Rhyphus, Lat. Antennæ projecting, subulate, sixteen-jointed, the two radical joints distinct: palpi exserted, incurved, four-jointed, the joints unequal, the second clavate: ocelli three, equal: legs unequal: wings parallel, incumbent.

R. *fuscatus*. Antennæ and palpi dark brown; head and thorax cinereous, the latter with three black lines, the central one longest: scutellum grey: abdomen of the males dark brown, with pale incisures, that of the female brownish yellow: halteres whitish: wings somewhat clouded, and having brown nervures, the stigma and a marginal spot fuscous. Male four, female three lines. Meig. *Zw.* i. pl. xi. fig. 18. ♀ Found in Britain, and is common in many parts of Europe.

B. Antennæ consisting of few joints.

FAMILY II.—XYLOPHAGI.

Antennæ projecting, approximating at the base, three-jointed, the third joint eight-ringed: proboscis retracted: ocelli three: abdomen composed of eight segments: halteres uncovered: wings parallel, incumbent; onychii three.

Genus Beris, Lat. (Plate CCXXXVIII. figs. 4 and 4 *a*.) Antennæ with the two radical joints short, third elongate, conical, eight-ringed: scutellum with many rays on the margin. Meig. Curtis. *Brit. Ent.* vii. pl. cccxxxvii.

B. *vallata*. Antennæ dark brown; head and thorax shining black: abdomen reddish yellow, that of the male having two black spots at the base; legs rufous, the hinder half of the tibiæ and the tarsi brown: wings of the female scarcely inclining to brownish, the base and anterior margin yellowish, the stigma dark brown. Two and a half lines. *Stratiomys clavipes*, Fab.; *Beris nigritarsis*, Lat. This species is found pretty frequently throughout the greater part of Britain. We have observed it near Edinburgh, and in Roxburghshire; and it occurs in Essex, Kent and other parts of the south of England. We have ascertained the existence of *B. femoralis*, *B. clavipes*, (Linn.), and *B. chalybeata*, in the south of Scotland; and seven others inhabit the more southern portion of the island.

Genus Xylophagus, Meig. Antennæ with the second joint cup-shaped, the third elongate, eight-ringed; proboscis retracted: scutellum unarmed.

X. *ater*. Shining black: first joint of the palpi yellow, second black: thorax of the males entirely shining black, that of the female with three grey vittæ, the lateral ones somewhat abbreviated: anterior legs bright yellow, with the apex of the tarsi brown; hinder legs bright yellow, the apex of the thighs, of the tibiæ and tarsi, brown; halteres yellow. Male five, female six lines. Meig. *Zw.* ii. pl. xii. fig. 14. Lat.; *Empis subulata*, Panz. Apparently the only species of the genus found in Britain.

Genus Cœnomyia, Meig. Antennæ with the radical joint elongate, cylindrical, second cup-shaped, third conical, eight-ringed: scutellum bidentate.

C. *ferruginea*. Rust brown: thorax with two lines of changeable white, which disappear behind the middle: abdomen dark rust brown anteriorly, paler behind; the second segment with a rather large white spot on each side behind, the two following with a similar spot, but united by a narrow white line; belly rust yellow, the hinder margins, with the exception of the first, whitish; legs ferruginous: halteres bright yellow: wings brownish yellow, with ferruginous nerves. Six to seven lines. *Tabanus bidentatus*, Fab. Gmel. Lat.; *Sicus ferrugineus*, Fallen. Not unfrequent in Germany and other continental countries in the months of June and July. It has not hitherto been observed in Britain.

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[1] For example, *Tipula Hortulana* of Linn. is the female of *B. Marci* described above.

[2] *Memoires*, t. v. p. 55, et pl. vii.

FAMILY III.—TABANII.

Antennæ projecting, approximating at the base, three-jointed; third joint from four to eight-ringed, or six-jointed: proboscis and palpi standing out: abdomen consisting of seven segments: halteres half covered: wings divaricating: onychii three.

a. Antennæ three-jointed.

Genus Pangonia, Fab. Antennæ with the basal joint cylindric, second cup-shaped, third elongate, subulate, eight-ringed: ocelli three: proboscis elongate, exserted: wings spreading.

P. *ferruginea.* Antennæ black, the second joint and base of the third yellow; proboscis black, the length of the thorax; the latter thickly covered with brownish-yellow pubescence: abdomen with similar pubescence, and marked with black spots on the back, the segments margined behind with whitish: belly rust-brown: wing-scales, halteres, and legs bright brown; thighs black: wings brownish. Eight lines. Lat. *Gen. Crust.* iv. 282. Inhabits Portugal. The genus contains six European species, none of which appear to occur in Britain.

Genus Silvius, Meig. Antennæ with the radical joint cylindrical, second cup-shaped, third subulate, five-ringed: ocelli three: palpi standing out, two-jointed, pilose, the second joint cylindrical in the male, conical in the female.

S. *Vituli.* Antennæ ochre-yellow, the apex black; hypostoma bright yellow; forehead of a similar colour, with a shining black callosity anteriorly in the female; palpi yellow, the apex black in the male: thorax yellow with a brown play of colour, pubescent: abdomen pubescent, yellow: wing-scales and halteres yellow, the knob of the latter whitish: wings with microscopic hairs, somewhat greyish, with the anterior margin yellow; legs yellow, with brown tarsi. Five to six lines. *Tabanus Vituli*, Fab.; *Tabanus Italicus*, Fab. This insect occurs on the continent, but we have no knowledge of its precise localities.

Genus Tabanus, Linn. (Plate CCXXXVIII. figs. 5 and 5 *a*). Antennæ with the basal joint cylindric, second cup-shaped, third compressed, the lowest ring very large and crescent-shaped at the base: ocelli wanting: palpi exserted, capitate in the male, subulate in the female: wings spreading.

T. *bovinus.* Antennæ black, reddish brown at the base: hypostoma, palpi, and forehead bright greyish yellow; the latter in the female with a black line, which terminates beneath in a shining black roundish callosity; eyes green during life: thorax dark brown, with yellowish hair, sometimes inclining to slate-colour, and having dark lines on the back: abdomen dark brown, with a rather wide reddish-yellow cross band on the hinder edge of the segments, and a row of bright yellow triangular spots down the middle: belly yellowish grey, darker behind the incisures, with rather large nearly triangular spots of black, and near these an oblique black line: thighs and tarsi dark brown; tibiæ bright yellow, the apex brownish: wing-scales and halteres brown, the apex of the latter pale; wings brownish, the anterior margin inclining to yellow. One inch. Linn.; Degeer, vi. 88. i. pl. xii. fig. 6–14. Common on the continent. It is not quite so plentiful in Britain, especially in Scotland, where we have seen it only on a few occasions in the northern and middle counties. We have taken it by the banks of Loch Katrine, and in Sutherland. Eighteen kinds of Tabani inhabit Britain, and upwards of twice that number are known as European. Besides *T. bovinus*, we are not acquainted with any other Scotch species except *T. tropicus* and *T. autumnalis*.

Latreille, Lepelletier and Serville, Meigen, Wiedemann, Macquart, and the late Palisot de Beauvis, have cleared away many of the difficulties which encumbered the systematic study of this and the allied genera; but their natural history, properly so called, has scarcely received any accession since the days of Degeer. It is to that great observer that we owe our knowledge of the manners and metamorphoses of the species above described, the only one in fact of which we have any detailed account. *T. maroccanus* is extremely troublesome to camels in the north of Africa. M. Defontaines has frequently observed their bodies entirely covered by these insects. The species occurs also in Portugal.

Genus Chrysops, Meig. (Plate CCXXXVIII. figs. 6 and 6 *a*). Named from χρυσος, *gold*, and ὄψ, *the eye*, which is usually very brilliant during life. Antennæ cylindrical, three-jointed, two basal joints equal, third longer, five-ringed: palpi exserted, two-jointed, pilose, the second joint conic: ocelli three: wings spreading.

C. *cœcutiens.* Male. Black; the eyes with two dark purple bands; the uppermost interrupted; hypostoma yellow, with large dark spots which nearly conceal the ground colour: forehead black: thorax with reddish pubescence on the sides and beneath: abdomen black, with a rufous spot on each side of the second segment; under side black brown, the two basal segments yellow, having a brown line in the middle: antennæ, palpi, legs, and halteres black: wings almost entirely brown; in the middle there is a small light-coloured spot; at the hinder margin, before the apex, a nearly uncoloured triangle, and not far from the base a pale mark.

The thorax of the female is lined with cinereous; the first segment of the abdomen has two yellow spots, the second is yellow, with two dark lines in the centre, enclosing a triangular mark of yellow behind: wings whitish; the base, anterior margin, a broad band rather behind the middle, and an apical spot, brown. Four lines. *Tabanus cœcutiens*, Linn.

Frequent in most countries of Europe. In Scotland it is rather scarce, but has been taken occasionally in Dumfriesshire, Roxburghshire, and elsewhere.

Genus Hæmatopota, Meig.; named from *αἷμα*, *blood*, and *ϖοτης*, *drinker*. Antennæ three-jointed, the second joint cup-shaped, third subulate, four-ringed: palpi exserted, two-jointed, second joint conic: ocelli wanting: wings parallel, deflexed. Meig. ii. 76. pl. xiv. f. 8–16.

H. *pluvialis.* Eyes greenish, with waved purple-brown bands: palpi and hypostoma light grey; antennæ scarcely longer than the head; first joint thick, oblong, shining-black, pubescent; thorax blackish, with whitish lines, the two next the middle having a white spot in the centre; sides of the breast light grey, somewhat pubescent: scutellum blackish, sometimes cinereous over the middle: abdomen blackish brown, with whitish incisures and a cinereous line down the back; on the third and following segments on each side of this line there is a round cinereous spot; in the males the three first segments are somewhat testaceous on the sides: belly brownish grey: thighs cinereous: anterior tibiæ yellow at the base, the apex, together with the tarsi, black brown; posterior tibiæ yellow, with three brown rings, one in the middle and another at each end; the tarsi black brown, with the first joint yellowish: halteres yellowish, having a brown spot on the knob: wings brownish-cinereous, with numerous waved lines of white, and a dark-brown marginal streak. Four to four and a half lines. Meig. ii. 78, pl. xiv. f. 16. *Tabanus pluvialis*, Linn. Very plentiful throughout Britain. This insect is known in Scotland by the name of *Cleg*, and is very troublesome during the heat of summer both to man and beast, particularly horses.

b. Antennæ six-jointed.

Genus Hexatoma, Meig.; named from ἓξ, *six*, and τόμος, *section*, in allusion to the number of joints in the antennæ. Antennæ six-jointed; the first and third joints elongate: palpi exserted, two-jointed; second joint capitate (in the male) or conical (in the female): ocelli wanting: wings parallel, deflexed. Meig. ii. 83, pl. xiv. f. 17–24. *Heptatoma*, Lat. *Gen. Crust.* iv. 284.

H. *bimaculata*. Hypostoma of the males shining-black, with yellowish hair; that of the female light grey above and yellow beneath; thorax blackish, with rufous pubescence: abdomen of the males black, the pubescence of the two basal segments brownish yellow; on the belly these segments are bluish white at the sides and blackish in the middle; the following black, with three pair of bluish-white transverse streaks: abdomen of the female black, the base with brownish-yellow pubescence, and the second segment with bluish-white lateral spots: feet black brown: wings vitreous. Six lines. *Tabanus pellucens*, Fab. A rare species, which has not yet been detected in Britain.

FAMILY IV.—LEPTIDES.

Antennæ porrect, approximating at the base, three-jointed; third joint without rings: proboscis and palpi exserted: ocelli three: abdomen consisting of seven segments: halteres uncovered: onychii three.

Genus Leptis, Fab. Antennæ with the first joint cylindric, second cup-shaped, third conic with an apical seta: palpi pilose, the second joint elongate: ocelli three, vertical: wings spreading.

L. *aurata*. Male. Hypostoma blackish grey; antennæ dark brown; thorax and abdomen thickly covered with shining golden hairs: halteres, thighs, and tarsi dark brown; tibiæ testaceous: wings pale brown, with the stigma reddish brown.

Female. Hypostoma and forehead dark grey, the latter broad: thorax and abdomen thickly clothed with light-yellow hairs; sides of the breast black; wings nearly hyaline, scarcely tinged with brown, the stigma reddish brown: halteres and legs as in the male. Three to four lines. *Rhagio atratus*, Fab. Lat.; *Rh. tomentosus*, Fab. In marshy meadows in May, common. This genus, as constituted by Meigen, contains twenty-two species; but more recent writers have separated it into two genera, corresponding to his sectional divisions. Nearly all of these inhabit Britain, and some are very abundant, particularly *L. scolopacea* and *L. tringaria*.

Genus Atherix, Meig. (Plate CCXXXVIII. figs. 7 and 7 *a*.) Antennæ with the terminal joint ovate, having a naked dorsal seta at the base: palpi standing out, pilose, incurved: ocelli three, vertical: wings spreading.

A. *Ibis*. Hypostoma and forehead bright yellow; the latter in the female yellowish with a brown vitta; thorax pubescent, yellowish brown, with broad lines of dark brown along the back; scutellum brown: abdomen of the males conical; the first segment dark brown, the following ferruginous with the hinder margin bright yellow, and marked with three black spots, one on the back and another on each side; on the last segments these spots run together; belly yellow: abdomen of the females ash-grey, the segments with a black band anteriorly, the hinder margin white; belly ash-grey: legs ferruginous, the tarsi brown at the apex: halteres yellow, the knob brown: wings hyaline, with irregular cross bands of reddish brown, which are paler in the female. Male four, female five lines. Curtis, *Brit. Ent.* i. 26; *Rhagio Ibis*, Fab.; ♀ *Atherix maculatus*, Lat.; *Anthrax Titanus*, Fab. Mr Curtis states that there are at present but two species of this genus recorded as natives of Britain, although twelve are enumerated as European. The species described appears to be everywhere rare. The male and female were placed by Fabricius in different genera.

Genus Clinocera, Meig. Antennæ remote, the lower joints spherical, the third conical with an incurved terminal seta: ocelli three, placed on the forehead: wings incumbent, parallel.

C. *nigra*. Head black; body dull black; thorax with three darker lines; legs long, slender, and black: halteres black, uncovered: wings hyaline. Two lines. Found in Germany and elsewhere.

FAMILY V.—XYLOTOMÆ.

Antennæ projecting, approximating at the base, three-jointed, the third joint without rings: proboscis concealed: ocelli three: abdomen seven-ringed, conical: halteres uncovered: wings spreading: onychii two.

Genus Thereva, Lat. Antennæ with the radical joint cylindrical, second cup-shaped, third conical: proboscis retracted: ocelli three: wings spreading.

T. *fulva*. Ferruginous, with pubescence of a similar colour, intermixed with black hairs on the thorax; two first joints of the antennæ ferruginous, the third dark brown: on the forehead of the females is the usual shining black spot, and the hinder extremity of the abdomen is likewise black: thighs and tarsi brown; tibiæ ferruginous: halteres yellow: wings nearly hyaline, the anterior border yellowish. Four to five lines. This insect is of not unfrequent occurrence in the south of Scotland, where *T. anilis* and *T. plebeia* are likewise found. The former is distinguished by its reddish thorax, and abdomen of a silvery-white or grey colour. It is generally seen sitting upon sand, but flies off suddenly if an attempt is made to seize it. Meigen mentions twenty species. Britain produces about one half of that number.

FAMILY VI.—MYDASII.

Antennæ projecting, five-jointed, the joints without rings, the terminal one club-shaped.

Genus Mydas, Lat. (Plate CCXXXVIII. figs. 8 *a* and 8 *b*.) Antennæ with the two lowest joints small, the following cylindrical, the terminal one clavate. Proboscis exserted.

M. *lusitanicus*. Entirely black, except the hinder edge of the abdominal segments, which are yellowish white: beard and mystax[1] white: the sides of the thorax and two first segments of the abdomen are beset with long white hairs, and the back of the abdomen and legs with short white pubescence: wings yellowish. Eight lines. Inhabits Germany, Portugal, &c. Another species, named

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[1] This term is applied to a semicircle of bristles or hairs placed over the mouth.

M. filatus, is found in America. It is figured by Drury.[1] Brazil produces one above two inches long.

FAMILY VII.—BOMBYLIARII.

Antennæ projecting, three-jointed; third joint without rings: hypostoma beardless: forehead flat: (proboscis retracted or somewhat projecting) ocelli three: abdomen consisting of seven rings, cylindric or elliptical: wings spreading: halteres uncovered.

Genus Hirmoneura, Wied. Antennæ remote, the joints sub-globose, equal, the third with a terminal style: ocelli three, the anterior one remote: proboscis retracted and concealed.

H. *obscura.* Hypostoma ochre yellow; forehead cinereous with blackish hairs: thorax black, with yellowish hairs on the sides, those on the breast more inclining to grey: abdomen with the lateral edges yellow, the upper side with yellowish grey pubescence, the apex of the segments slate grey; belly yellowish, and covered with pubescence similar to that on the breast: wings brownish grey, especially at the anterior margin: halteres dark brown: legs ochre yellow, the tibiæ and tarsi a little darker: extremity of the abdomen with two short truncated styles. Seven and a half lines. Found in Dalmatia.

Genus Fallenia, Meig. Antennæ remote, the joints sub-globose, the last with an elongate terminal style: proboscis the length of the body, and bent beneath the breast.

F. *caucasica.* Head and thorax covered with whitish hair; eyes of a metallic hue: abdomen nearly orbicular, with blackish pubescence; the first segment wide, with grey pubescence, the following fringed with whitish grey upon the hinder edge; the anus ferruginous: wings yellowish: legs brownish grey, with rather indistinct grey hairs. Five to five and a half lines. *Volucella caucasica*, Wied. *Zool. Mag.* i. 2, 7. Found in Russia and elsewhere, but appears to be scarce. There is only one other species, *F. fasciata*, Fab. a native of Italy.

Genus Stygia, Meig.[2] Antennæ approximating, the first joint dilated at the apex, and obliquely truncate, second cup-shaped, third conical: head sub-globose; eyes kidney-shaped: proboscis retracted.

S. *Belzebub.* Male. Hypostoma and forehead black, the last having a tendency to pass into grey over the antennæ: thorax wholly shining black, with pubescence of the same colour: abdomen shining black, the hinder margin of the segments (with the exception of the first) narrowly edged with yellow; the pubescence on the sides of the first segment whitish, and on the following black: belly entirely black: wing-scales black, fringed with white hair: stalk of the halteres brown, the knob pale yellow: legs black. Five to six lines. *Anthrax Belzebub*, Fab. This fly is found in France, Italy, Hungary, England, and in most other parts of Europe.

Genus Anthrax, Scop. (Plate CCXXXVIII. figs. 9 and 9 *a.*) Antennæ distant, the first joint cylindrical, second cup-shaped, third sub-globose, with an elongate or conical style; eyes kidney-shaped: proboscis retracted or very slightly produced.

A. *flava.* Hypostoma with bright yellow pubescence; forehead black, with short rufous hairs, which are mingled with black ones: antennæ black: thorax and abdomen covered throughout with long reddish shining hairs, the anus having pale yellow hairs, and three black tufts: stalk of the halteres brown, the knob yellow: wings hyaline, with a yellowish-brown streak along the anterior edge, and the base with a pectinated mark of black: wing-scales brownish yellow: legs black; thighs and tibiæ sprinkled with yellow. Seven lines. *Anthrax hottentotta*, Fab.; *Musca hottentotta*, Don. xiv. 69, pl. ccccxciv. Inhabits England, France, and Holland, occurring not unfrequently. This genus, as constituted by Meigen, contains about sixty species, a small proportion of which has yet been detected in Britain. We know little of their history or transformations.

Genus Mulio, Lat. Antennæ distant, the first joint short and cylindrical, second cup-shaped, third conical, acute; eyes elliptical: proboscis standing out, horizontal.

M. *infuscatus.* Hypostoma with ash-grey hairs; the forehead with dark-brown hairs; proboscis as long as the head: thorax dark brown, ash-grey on the sides: abdomen flat and arched, with ferruginous hairs, the incisures beset with numerous black bristles; halteres brown, the knob almost entirely white; wings light brown, the apex hyaline: legs yellow and glistening; the tarsi brown. Three and a half lines. Found in Provence by M. Baumhauer.

Genus Bombylius, Linn. (Plate CCXXXVIII. figs. 10 and 10 *a.*) Antennæ approximating, the first joint cylindrical, second cup-shaped, third elongate and compressed; proboscis standing out, longer than the head: body woolly.

B. *minor.* Beard whitish; mystax reddish: the sides covered with black hairs: forehead of the females with reddish hair: antennæ and proboscis black: ground colour of the body deep black, the whole surface covered with rufous hairs: halteres dark brown; wings somewhat greyish, the base and anterior margin more or less rufescent. Four lines; the proboscis from two and a half to three lines. Fab. Linn. Found in several parts of England: we have often observed it in considerable abundance on the sides of Arthur's Seat, and in the fields to the south of Duddingston. About six other species occur in Britain; and although the appearance of these is very familiar, naturalists in truth know little or nothing of their transformations. Latreille supposes that their larvæ are parasitical. Nearly fifty European species are described by systematic authors.

Genus Phthiria, Lat. Antennæ approximating, the two lower joints short and equal, the third elongate, spindle-shaped, compressed: proboscis standing out, horizontal, elongate: palpi clavate.

P. *minuta.* Male. Hypostoma and forehead black, and covered with black hairs: body wholly deep black, with soft and rather long black hairs: wings smoke-brown, the stigma brown: halteres and legs black.

Female. Hypostoma white; the forehead blackish, the margin of the eyes white: body black, with traces of white hairs; scutellum yellow, having a dark-brown streak along the sides: under side of the breast whitish; halteres brown above, white beneath: wings brown, but considerably paler than those of the male: legs black. One and a half line. Lat.; *Volucella minuta*, Fab. Occurs, along with five other species, on the continent of Europe.

Genus Geron, Hoff. Antennæ approximating, the first joint elongate, cylindrical, second cup-shaped, third

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[1] *Illustrations*, vol. i. tab. 44, fig. 1.

[2] The name of this genus is defective, in as far as it has been already applied to a lepidopterous genus. Meigen has since altered it to *Lomatia*, which is scarcely more fortunate, as it also has been previously applied by Mr Brown to a genus in botany of the family of Proteaceæ. Latreille has altered the original designation to *Stygides.*

Diptera Proboscideæ.

cylindric-subulate: proboscis standing out, horizontal, elongate.

G. *gibbosus*. Hypostoma and forehead white; antennæ black; thorax whitish grey, with two wide lines of brownish black down the back: scutellum and abdomen black: halteres white; wings hyaline, inclining to pale yellow at the anterior border: legs dark grey. Two and a half lines. Has been found in Bucharia by M. Baumhauer in the month of July.

Genus Usia, Lat. Antennæ approximating, the first joint sub-cylindrical, very short; second cup-shaped; third spindle-shaped, elongate, obtuse: proboscis standing out, elongate, horizontal, acute.

U. *ænea*. Dark brassy: forehead white anteriorly, greyish behind, with a shining black vitta; hinder part of the head cinereous, and marked with a shining black streak in the centre: wing-scales and halteres white: abdomen finely pubescent, wide, flat, and arched; the belly whitish yellow, marked with black cross bands which are abbreviated at the sides: wings hyaline, with a yellow base and a large black spot near the middle of the anterior margin: legs black, with a metallic lustre. Two and a half to three lines. Lat. *Gen. Crust.* iv. 315. Found near Bourdeaux and elsewhere.

Genus Ploas, Fab. Antennæ approximating, the first joint very thick and conical, second cup-shaped, third spindle-shaped, and furnished with a jointed style at the apex; proboscis standing out, horizontal, the length of the head.

P. *grisea*. Colour varying from black to slate-grey: thorax marked with four grey lines, the two in the middle united anteriorly: halteres white: abdomen griseous: wings brownish at the base and anterior margin. Three and a half lines. *Bombylius griseus*, Fab. Inhabits Germany, Spain, &c.

Genus Cyllenia, Lat. Antennæ approximating, the first joint cylindrical, second very short, cup-shaped, third conical with a simple style at its apex: eyes oval: proboscis somewhat standing out, horizontal.

C. *maculata*. Antennæ with the radical joint brownish grey, second white, the third black: forehead black, the margin of the eyes white: thorax black, with yellowish-grey pubescence, mixed with long black hairs: abdomen with the first segment brown, the following pale yellow anteriorly, brown behind, with reddish-yellow hair and long black ones intermixed; on each segment are two longitudinal lines of black, diverging behind, and a black spot: halteres pale yellow above, brown beneath: legs black, covered with matted hair of a ferruginous colour: wings pale brown at the anterior edge, and sprinkled over the surface with dark-brown spots. In the male the hinder thighs are much thicker than in the female. Three to four lines. Lat. *Gen. Crust.* iv. 312. The species described is the only one belonging to the genus. It appears to be more frequent in France than in any other European country.

Genus Toxophora, Meig. Antennæ longer than the head, approximating, the two lower joints cylindrical, the third conical; proboscis standing out, arched, one half longer than the head; the palpi slender, cylindrical, bent and acute.

T. *maculata*. Hypostoma white, the hinder part of the head of a similar colour; thorax black, covered with a sulphur-coloured down on the sides and back: abdomen clothed in a similar manner, and having two rows of naked black spots down the back: legs black, with white down, the tibiæ somewhat bristly: halteres white, uncovered: wings hyaline, the anterior margin and the base yellowish. Four lines. This rare fly has been found in the south of France and in Russia. It appears to have been formerly described by Villers under the title of *Asilus fasciculatus*.[1] It was brought from Syria by Labillardière, and is justly admired as a beautiful and interesting species.

The genus is widely distributed, and probably requires subdivision. We have received species from Brazil. Meigen Le Conte has taken it in the United States. Wiedemann describes a species from Java; and *Bombylius cupreus* of Fab. which is now regarded as a Toxophora, is native to Cayenne.

FAMILY VIII.—ASILICI.

Antennæ projecting, approximating at the base, turned upwards, three-jointed; the third joint without rings: hypostoma with a mystax: forehead depressed: proboscis projecting horizontally, short: abdomen consisting of seven segments: halteres uncovered: wings parallel, incumbent.

a. Tarsi with two onychii.

Genus Dioctria, Meig. Antennæ inserted into a frontal tubercle; first joint cylindric, second shorter, somewhat cup-shaped; third elongate, compressed, the apex with a blunt two-jointed style: proboscis exserted, short, nearly horizontal: hinder legs straight, ciliated beneath: wings incumbent.

D. *rufipes*. Shining black: hypostoma bright brass-yellow, shining: on the thorax are two changeable white lines, which, however, are scarcely observable in the males; the sides of the thorax with silvery streaks: halteres yellow: legs rufous, the hinder pair dark brown: wings hyaline. Six to seven lines. *Asilus rufipes*, Degeer. Not a rare insect throughout England: in Scotland it is far from scarce, and *D. lateralis* frequently occurs in company with it. Meigen describes twenty-eight species, eleven of which have been detected in Britain.

Genus Dasypogon, Meig. (Plate CCXXXVIII. figs. 11 and 11 *a*). Named from δασυς, *hairy*, and πωγων, *a beard*. Antennæ with the two lower joints sub-cylindric, equal, third elongate, compressed, somewhat spindle-shaped, the apex with a short two-jointed style: proboscis horizontal, the length of the head: tibiæ straight.

D. *ruficornis*. Thickly pubescent: antennæ ferruginous, black at the base; mystax ferruginous, the forehead dark brown: thorax shining brownish black, with yellowish-grey spots, and having white hairs anteriorly: scutellum black: abdomen deep black, shining, the hinder half of the second segment and the whole of the third and fourth dull ferruginous, the fifth in the female with a ferruginous margin behind: belly shining black; legs very hairy, dark brown, the tarsi reddish brown: halteres brown, with a yellow knob. Seven to eight lines. *Asilus ruficornis*, Fab.; Meig. *Zw.* ii. pl. xx. fig. 11. This insect occurs in France. The genus contains forty-four European species, only two of which, viz. *D. punctatus* and *D. brevirostris* (Curtis, *B. E.* fol. 153), have been noticed in Britain.

Genus Laphria, Fab. Antennæ with the radical joint cylindric, second cup-shaped, third clavate, obtuse: proboscis standing out, horizontal: tibiæ arched.

L. *gibbosa*. Beard pale-yellow, with a brownish play of colour: thorax black, with reddish-brown hairs: three first segments of the abdomen shining black, the three following clothed with whitish-yellow down; the seventh black, retracted: belly and legs black, the latter with brown pubescence: nervures of the wings margined with yellowish brown: halteres black. Ten lines. *Laphria gibbosa*, Fab.; *Asilus gibbosus*, Fab. Found in various parts of Europe. *L. nigra* (Curtis, *B. E.* fol. 97) is the only species of the genus, which contains thirty-two different kinds, satisfactorily ascertained to inhabit Britain. It has been found in Darent Wood, Kent, in the vicinity of London, and at Coombe Wood.

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[1] *Entom. Lin.* iii. pl. 10, fig. 31.

GENUS ASILUS, Linn. Antennæ with the basal joint cylindric, second cup-shaped, third subulate, compressed, having a setiform apical style: proboscis exserted, horizontal: tibiæ straight, spinulose.

A. *crabroniformis*. Head yellow: two basal joints of the antennæ rufous, third brown: thorax rufous, with two brown dorsal lines, which are usually obsolete, behind: scutellum brown: three basal segments of the abdomen deep black, the second incisure with a white spot on each side; the remaining segments rufous, with a fine glistening lustre; that of the female bent downwards and terminating in a black style: legs rufous, with brownish thighs: halteres brownish yellow: wings pale yellow, the hinder margin spotted with fuscous. One inch nearly: the male rather less. Meig. ii. 309; Linn. *Fauna Suec.* 1908. Occurs throughout Europe, and in some countries of Asia. The genus is extensive (containing nearly sixty European species), and a considerable number inhabit Britain,—some of them being rather common. *A. opacus* abounds in several parts of Scotland. All the species are carnivorous, and prey upon other Diptera. They even attack hymenopterous insects. Their flight is rapid, and frequently attended by a buzzing sound. They occur in woods and various other places, chiefly in autumn, or the end of summer. Their structure and metamorphoses have been illustrated by Frisch,[1] Degeer,[2] and Marcel de Serres.[3] The larvæ live under ground.

b. Tarsi without onychii.

GENUS LEPTOGASTER, Meig. Antennæ with the two lowest joints short, cylindrical, equal; third conical, with the apex pilose: proboscis horizontal, short.

L. *Pallasii*. Naked: thorax slate-grey, black when seen in certain directions; sides of the breast whitish: first segment of the abdomen very small; the last nearly club-shaped, all of them margined with light grey: legs pale yellow, with a ring on the thighs, the apex of the tibiæ and the tarsi brown: hinder legs much longer than the anterior ones, club-shaped, with a ring near the apex: halteres pale: wings with the lower half brown, the remainder hyaline. Four and a half lines. Found in the south of Russia. It is rare.

FAMILY IX.—HYBOTINÆ.

Antennæ projecting, approximating at the base, three-jointed: the first two joints united so as to form one, the third without rings: hypostoma beardless, flat: forehead flat: proboscis projecting horizontally, short: thorax much arched: abdomen slender, consisting of seven rings: halteres uncovered: wings parallel, incumbent.

GENUS HYBOS, Fab. Antennæ with the two lowest joints united, cylindrical; the third conical, with a pubescent seta at the apex: hinder thighs thickened.

H. *funebris*. Black, with a whitish hypostoma, and pale yellow halteres: thorax with a white play of colour behind: wings with a dark-brown stigma. Two lines. *Asilus culiciformis*, Fab. Common everywhere in hedges and among grass. Four other species in addition to the above are indigenous to Britain.

GENUS OCYDROMIA, Hoff. (Plate CCXXXVIII. figs. 12 and 12 *a.*) Antennæ with two lowest joints united, cylindrical; third lenticular, bearing a seta at the apex: proboscis sub-exserted, horizontal: all the legs simple.

O. *flavipes*. Antennæ dark brown; palpi yellow: thorax and abdomen entirely black: halteres yellow: legs yellow, all the tarsi brown; the hinder coxæ, the apex of the hinder thighs, and the tibiæ, are likewise brown: wings somewhat brownish. Three lines. Found in England and on the continent.

GENUS OEDALEA. Antennæ with the first joint cylindrical, short; second cup-shaped, third elongate, conic, compressed; proboscis short and horizontal: hinder thighs thickened and spinose beneath.

O. *minuta*. Body black, finely pubescent, shining: halteres brown: legs pale reddish yellow; in the anterior pair the tibiæ and tarsi are brown, and in the hinder pair the tarsi only are of that colour: wings brownish, with a long brown stigma. One and a half line. *Empis minuta*, Fallen. Found in Britain, France, &c.

FAMILY X.—EMPIDIÆ.

Antennæ porrect, approximating at the base, three-jointed, the third joint without rings, and having a style or a seta at the apex: hypostoma beardless: ocelli three: proboscis exserted, very perpendicular, with incurved palpi: abdomen consisting of seven segments: wings parallel, incumbent: onychii two. Meig. iii. 1.

GENUS HILARA, Meig. (Plate CCXXXVIII. figs. 13 and 13 *a.*) Antennæ with the basal joint cylindric; second cup-shaped, third subulate, compressed, the apex with a two-jointed style: proboscis thick, shorter than the head: wings incumbent, parallel, with an oblique transverse nervure at the apex. Meig. *Zw.* iii. pl. xxii. f. 1–5.

H. *cilipes*. Dusky black, antennæ reddish brown: wings fuscous; halteres whitish; the anterior metatarsus of the male dilated in an elliptical form, and fringed on the external margin with long hairs. Two lines. Meig. *Zw.* iii. 3, pl. xxii. fig. 3; Curtis, *B. E.* 130. Found near London. Upwards of twenty species belong to the genus, and nearly all of them inhabit Britain.

GENUS BRACHYSTOMA, Meig. Antennæ with the first joint cylindric, second cup-shaped, third conic, with a very long terminal seta: proboscis the length of the head: wings incumbent, parallel.

B. *vesiculosa*. Hypostoma greyish white; forehead narrow, black: antennæ as long as the head, black; the two first joints of equal length, the third with a long apical seta bent downwards: proboscis perpendicular, nearly as long as the head: thorax shining black, cinereous on the sides: scutellum very small: abdomen cylindrical, black; the seventh segment very much inflated, pellucid, waxen yellow: halteres white: wings hyaline, with a scarcely perceptible pale marginal streak: coxæ cinereous, short; thighs ferruginous; tibiæ at the base, and the tarsi, brown. Two and a half lines. *Baccha vesiculosa*, Fab. Inhabits Britain and the continent of Europe.

GENUS GLOMA, Meig. Antennæ with the first joint cylindric, very slender, second cup-shaped; third globose, with an apical seta: proboscis the length of the head, thick.

G. *fuscipennis*. Antennæ black; thorax of the same colour, pubescent: abdomen pubescent, black brown, with yellowish incisures: halteres brown: wings brown, with a dark marginal streak; legs pubescent, brown; all the thighs and the hinder tibiæ with a groove on both sides; the hinder legs as long as the anterior ones. Two lines. Meig. *Zw.* iii. pl. xxii. fig. 11. Inhabits England, but is very scarce.

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[1] In his work on the *Insects of Germany*.

[2] *Mémoires*, t. vi.

[3] *Annales du Mus. d'Hist. Nat.* t. iv. p. 361.

Genus Empis, Linn. Antennæ with the basal joint cylindric, second cup-shaped, third conic, compressed, the apex with a two-jointed style: proboscis perpendicular or bent inwards, longer than the head, slender: wings with a transverse nervure at the apex, incumbent, parallel. Meig. *Zw.* iii. 15, pl. xxii. fig. 13–20; Curtis, *B. E.* pl. xviii.

E. *tessellata.* Palpi, antennæ, and proboscis black, the latter as long as the head and thorax: hypostoma and forehead cinereous; thorax of the same colour, bristly, with three dorsal lines black, the central one narrowest: abdomen hairy, cinereous, with a line down the back, and the hinder margin of the segments blackish; when seen in another direction both colours change, the black becoming grey and the grey black: halteres yellowish: wings brown, ferruginous at the base: legs black, the tibiæ testaceous, shining. Five to six lines. Meig. Fab. *E. livida*, Fab. var. Common on flowers, during summer, in England and Scotland, and most parts of Europe: it has been likewise taken by Pallas in Tauria. Twenty-eight species of Empis occur in Britain, and nearly double that number are known to entomologists. Their early states have not been well determined. In the perfect state they prey upon other flies.

Genus Rhamphomyia, Hoff. Antennæ with the radical joint cylindric, second cup-shaped, third conic, compressed, the apex with a two-jointed style: proboscis perpendicular or bent inwards, slender: wings incumbent, parallel, the transverse nervure at the apex wanting. Meig. *Zw.* iii. 42.

R. *longipes.* Deep shining black, as well as the legs: proboscis twice the length of the head, slender: halteres dark brown: wings hyaline, with a scarcely perceptible stigma: in the males the hinder legs are stout, elongate, and pubescent; the hinder tibiæ somewhat clavate, and the first joint of the tarsi distinctly thickened: in the female the anterior legs are simple. Found in summer, but is rare.

FAMILY XI.—TACHYDROMIÆ.

Antennæ porrect, approximating at the base, two-jointed, with an apical seta: ocelli three: proboscis short, perpendicular: palpi incumbent on the proboscis: abdomen consisting of seven segments: onychii two.

Genus Hemerodromia, Hoff. (Plate CCXXXVIII. figs. 14 and 14 *a*). Antennæ with the first joint cylindric, second ovate, the apex supporting a seta: proboscis short and perpendicular, with incumbent palpi, which are subulate or cylindric: anterior coxæ elongate: wings incumbent, parallel. Meig. *Zw.* iii. 61, pl. xxiii. fig. 5–15.

H. *monostigma.* Yellowish white: forehead cinereous: on the thorax are two cinereous vittæ, which anteriorly are drawn into two black lines: along the back of the abdomen runs a black line, which is notched or sinuated on both sides: the fifth joint of the tarsi is black; wings hyaline, with a marginal spot of black. Two lines. Meig. *Zw.* iii. pl. xxiii. fig. 6. Found in the south of England and elsewhere.

Genus Tachydromia, Meig. *Sicus*, Lat. Antennæ with the first joint cylindric, second ovate or oblong, with a terminal seta: the anterior or intermediate thighs thickened: wings incumbent. Meig. *Zw.* iii. pl. xxiii. fig. 16–24.

T. *fasciata.* Palpi yellow, proboscis black; hypostoma white; forehead cinereous; antennæ black, with the basal joint yellow: thorax cinereous: abdomen shining black, with a broad cinereous ring, interrupted in the middle, at the base of each segment: halteres bright yellow: legs rufous, the tarsi black at the apex: wings yellowish. Two lines. Meig. *Zw.* iii. pl. xxiii. fig. 22. Has been taken by Dr Leach in England, where thirty-three other species occur. Few of these have been ascertained to inhabit Scotland. *T. minuta*, however, has lately been found near Edinburgh. There are about sixty species in Europe.

Genus Drapetis, Meig. Antennæ with the first joint cylindric, second lenticular, with a seta at the apex: proboscis scarcely exserted, very short, perpendicular, covered by the palpi: wings incumbent, parallel. Meig. *Zw.* iii. pl. xxiii. fig. 25–28.

D. *exilis.* Head black, nearly round; antennæ black: thorax shining black, without a transverse suture above: abdomen of the males entirely shining black, rather long, nearly cylindric; that of the female more oval, pointed, reddish yellow above, with a black transverse band at the hinder margin of the segments, entirely ferruginous yellow beneath: thighs somewhat thickened, black; tibiæ brown, unarmed; tarsi yellow: halteres black: wings hyaline. Male half a line, female three fourths of a line. Said to be common in hedges during the months of August and September, in various parts of the continent.

FAMILY XII.—INFLATÆ.

Antennæ very minute, two-jointed: head almost entirely occupied by the eyes: ocelli three: abdomen very thick, consisting of five segments: onychii three.

Genus Cyrtus, Meig. *Acrocera*, Fab. Antennæ nearly vertical, the first joint cylindric, second ovate with a terminal seta: proboscis exserted, horizontal, longer than the head. Meig. *Zw.* iii. pl. xxiv. fig. 1–6.

C. *gibbus.* Proboscis and palpi yellow: thorax nearly globose, arched, pubescent, yellow, with a black dorsal line anteriorly, which is widened in the middle into a large spot: scutellum semicircular, black, with a triangular spot of yellow at the hinder margin: abdomen very thick, inflated, globular, flat beneath, of a yellow colour, with four black cross bands produced in the middle into a point: wing-scales large and cinereous; the halteres small, and yellow: wings lanceolate, hyaline, yellowish at the anterior margin: legs ferruginous. Four to five lines. A rare insect, found occasionally in the south of Europe and in the north of Africa. The species in general frequent flowers.

Genus Acrocera, Meig. Antennæ vertical, the second joint spindle-shaped, with a terminal seta: proboscis concealed. Meig. *Zw.* iii. pl. xxiv. fig. 7–10.

A. *sanguinea.* Thorax black, naked, with a white spot on the shoulder, and a whitish line before the wing-scales: abdomen blood-red, with four dorsal spots, the three anterior ones triangular: legs black: wing-scale blackish brown: wings brownish, the marginal nervures dark. Three and a half lines. Meig. *Zw.* iii. pl. xxiv. fig. 10. The species are few in number, and frequent moist places. The one just described is found on the continent. Two others, *A. globulus* and *A. albipes*, inhabit England.

Genus Henops, Illig. (Plate CCXXXVIII. figs. 15 and 15 *a.*) Antennæ porrect, inserted into the upper margin of the mouth, the basal joint patelliform, second ovate, with a terminal style thickened at the apex: proboscis concealed.

H. *marginatus.* Thorax black, with fine grey pubescence: abdomen black brown or pitch colour, the hinder margin of the segments white: legs entirely rufous: wing-scales and wings hyaline, the last with yellowish-brown

Diptera Proboscideæ.

marginal nervures: belly white, with dark-brown bands. Two to three lines. Meig. *Zw.* iii.; Curtis, *Brit. Ent.* pl. cx. This species has been frequently taken in the New Forest.

FAMILY XIII.—STRATIOMYDÆ.

Antennæ porrect, approaching at the base, three-jointed; third joint ringed: proboscis along with the head projecting: ocelli three: abdomen with five segments: onychii three.

Genus Pachygaster, Meig.; named from παχυς, *thick*, and γαστερ, *the belly*. Antennæ with the third joint globose, four-ringed, and having a terminal seta: scutellum unarmed. Meig. *Zw.* iii. pl. xxiv. fig. 16–23.

P. *ater.* Antennæ of the males brownish, of the females rufous: forehead of the males triangular, small, shining white, with a longitudinal furrow; the crown with three ocelli: thorax rather elongate, black; scutellum unarmed: abdomen wider than the thorax, arched above, flat beneath, black, naked: legs pale yellow with black thighs: halteres with a yellowish stalk and a black-brown knob: wings lanceolate, microscopically pubescent, when in a state of repose lying parallel with the body; the basal half brown, the rest hyaline. Two lines. *Vappo ater*, Lat. Leach. Not a scarce insect on the continent, and in this country it has been found in Darent, Birch, and Coombe Woods, besides various other places. The larva is elongated, of a reddish grey, marked with three obscure longitudinal bands.[1] Another British species is represented in Curtis' *Brit. Ent.* fol. 42, and named after Dr Leach, by whom it was discovered in Devonshire. The most obvious mark of distinction is derived from the appearance of the wings, which are uniformly hyaline in *P. Leachii*, while the lower half is brown in *P. ater*.

Genus Sargus, Fab. (Plate CCXXXVIII. figs. 16 and 16 *a.*) Antennæ with the first joint sub-cylindric, second cup-shaped, third lenticular, three-ringed, having an apical seta: scutellum without spines. Meig. iii. 104; Lat. *Gen. Crust.* iv. 278.

S. *Réaumuri.* Male. Head black; forehead with two white spots over the antennæ, the latter black brown; eyes green, without purple bands: thorax shining brassy green above, with a longitudinal line of white on each side: abdomen bright copper colour, with yellowish white pubescence: halteres and feet rufescent, the tarsi brown at the apex: wings reddish brown, the stigma somewhat obscure. Six lines. Meig. iii. 109; Réaumur, *Ins.* iv. 22, pl. 5–8.

The female is considerably less than the male, and is strikingly distinguished by having the abdomen of a bright steel blue, with the two basal segments red, having a narrow steel-blue line on the back. This sex is figured by Mr Curtis, *B. E.* pl. cccv. This beautiful species has been taken occasionally in England, and has been observed oftener than once near Edinburgh. On one occasion Mr Duncan found both sexes abundant in an open wood on the banks of the Teviot. All the species hitherto described occur in Britain, excepting two. Several, particularly *S. infuscatus*, *S. politus* (*Musca polita*, Linn.), and *S. formosus*, are common throughout the south of Scotland, the two former frequenting woods and gardens, the latter marshy meadows. *S. flavipes* (Meig. pl. xxvi. f. 14), which appears to be one of the rarer species, has been captured among the Pentland Hills.

The insects of this genus delight in warm and sunny weather. During cloudy days they may be found upon the leaves of various plants, dull, inactive, or in a state of stupor. One of the larvæ has been described by Réaumur. Its form was oblong-oval, narrowed to a point in front; the head scaly, furnished with a couple of hooks; the body thinly beset with hairs. It was found in cow-dung. It became a chrysalis without changing its skin, and the perfect insect made its exit by knocking off the anterior lid of its hardened envelope. Macquart divides the genus into two sections.

Genus Nemotelus, Fab. Antennæ inserted into the apex of a conical hypostoma, the lower joints equal, third elongate, spindle-shaped, four-ringed, the apex with a two-jointed style: scutellum without spines. Meig. *Zw.* iii. pl. xxv. f. 16–20.

N. *uliginosus.* Male. Forehead black, with a whitish spot over the antennæ: thorax shining black, with fine cinereous pubescence, and a white vitta extending from the shoulder to the base of the wing: scutellum black: abdomen white, black at the base, and having a spot of the same colour before the apex: legs white; thighs black, with a white apex; hinder tibiæ black, white at the base and apex: halteres white: wings hyaline, the marginal nervures yellowish.

Female. Shining black: head with short whitish silken hair, and an interrupted cross band of the same colour over the antennæ: thorax with short whitish silky pubescence, the shoulders and a line on each side running to the base of the wings, white: abdomen surrounded with yellowish white, and marked with three rows of triangular spots, the side rows united to the yellowish margin: in other respects like the male. Three lines. Meig. *Zw.* iii. 114, pl. xxv. fig. 19, *female.* *Musca uliginosa*, Linn.; Don. xv. 31, pl. 519.

Found in meadows and marshy places, in Britain and on the continent of Europe.

Genus Clitellaria, Meig. Antennæ with the two lowest joints nearly equal, the third conic, five-ringed, with a two-jointed terminal style. Meig. *Zw.* iii. pl. xxv. f. 21–25.

C. *Ephippium.* Hypostoma and forehead black, the latter in the female with two whitish pubescent spots: antennæ black brown: thorax covered with a silky pile of a fiery red colour, the sides and breast black; before the base of the wing there is a black pubescent spine: scutellum black, with two pubescent spines rising from the hinder edge: abdomen black: halteres yellow: wings smoke colour, deepening at the anterior edge: legs black, the hinder tibiæ somewhat crooked. Five lines. Meig. *Zw.* iii. pl. xxv. f. 25. Inhabits Germany, France, Switzerland, and England.

Genus Oxycera, Meig. Antennæ with the two lowest joints equal; third spindle-shaped, four-ringed, with a two-jointed terminal style: scutellum armed with two spines.

O. *pulchella.* Male. Hypostoma black, with whitish-grey pubescence: eyes with a purple fascia: forehead with two silver-white pubescent spots: antennæ black: thorax black: from the shoulder extends a yellow vitta to the base of the wings, where it turns downwards somewhat pointedly; behind the base of the wing towards the scutellum there is a yellow triangle: scutellum and spines yellow, the latter with a blackish apex: abdomen black, each side of the third and fourth segment with a long spot of a fine yellow colour directed forwards, and a triangular one on the terminal segment: belly black, the second, third, and fourth segments yellowish in the middle: legs yellow: thighs black in the middle: the anterior tarsi with the four last, and the others with the three last joints, blackish brown: halteres yellow: wings hyaline, the nervures brown.

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[1] Macquart, *Dipt. du Nord de la France*, p. 112.

Female. Hypostoma and forehead yellow, with a black vitta in the middle; crown black; hinder margin of the eyes yellow: on the first segment of the abdomen, beneath the scutellum, is a yellow spot: in other respects the same as the male. Three lines. Meig. *Zw.* pl. xxv. f. 29; *Musca hypoleon*, Don. v. 6, pl. cxlvi. f. 3. Found in summer on hedges and bushes near lakes and marshes.

Genus Stratiomys, Geoff. Antennæ with the second joint cup-shaped, third elongate, somewhat spindle-shaped, five-ringed: scutellum armed with two spines.

S. *Potamida.* Thorax fuscous; scutellum with a black band at the base, the spines entirely yellow: abdomen black, the second segment with a yellow triangular spot on both sides, and on the hinder margin of the third segment there is a narrow band of yellow, which is broad and interrupted in the males, but entire in the females; the following segments have a narrow band in both sexes, and the anal one is marked with a yellow triangle: the belly is dirty yellow marked with four bands of black, the first one interrupted. From six to seven lines. *Musca Chamæleon*, Harr. *Ex.* 44, pl. xi. fig. 1. Of occasional occurrence in Britain, and on the continent of Europe. *S. Chamæleon* is more frequently met with in this country, particularly in the more northern parts.

The manners of these insects have been studied by Geoffroy and Réaumur. The larvæ have a long flattened body, covered by a coriaceous or rather solid skin, divided into segments, of which the last three, more slender and elongated than the others, form a tail terminated by a radiated expansion of barbed or plumy hairs. The head is scaly, small, oblong, and provided with a great many appendages and hooks, with which they agitate the water in which they dwell. They respire by an opening in the caudal segment, while suspended from the surface. Their skin becomes the cocoon of the nymph. The latter scarcely change their form, but they assume a rigid consistence, and become incapable of motion. They float upon the water, and their tails frequently form a right angle with the body. The perfect insect issues from a cleft which opens in the second ring. The species are few in number. About half a dozen are found in Britain.

FAMILY XIV.—SYRPHICI.

Antennæ three-jointed; third joint compressed, not ringed, with an apical style, or a dorsal seta at the base: ocelli three: proboscis concealed: abdomen with five segments: onychii two.

a. Antennæ with a terminal style.

Genus Callicera, Meig. Antennæ inserted on a common tubercle, the first joint cylindrical, second of equal length, compressed and dilated at the apex, the third terminating in an acuminated style: abdomen conical: wings incumbent, parallel.

C. *ænea.* Hypostoma yellow and pubescent, having a black line down the middle: thorax pubescent, of a yellow colour, blackish on the back, and marked with three obscure lines: scutellum blackish, the pubescence yellowish white: abdomen shining brassy green, with yellow pubescence, of a conical form in the male, more rounded in the female, and in the former marked with a black nearly triangular spot at the base: legs yellow, the thighs almost entirely black. Males five and a half, females nearly seven lines. *Bibio ænea*, Fab.; *Musca ænea*, Gmelin.

This insect has occurred at Berlin and in the south of France.

Genus Ceria, Fab. Antennæ seated on a common footstalk; the basal joint cylindrical, second and third equal, clavate, compressed, and furnished with an apical style: abdomen cylindrical: wings divaricating?

C. *conopsoides.* Shining black and pubescent: peduncle of the antennæ elongate, and ferruginous; thorax with the shoulders and a small spot near the base of the wings yellow: abdomen with a yellow band on the hinder margin of the second, third, and fourth segments: legs rufous, the thighs brown. Five to six lines *Ceria clavicornis*, Fab.; *Musca conopsoides*, Linn.; Curtis, *B. E.* 186 ♀. Very rare in Britain, but not unfrequent on the continent. There is an English specimen in the British Museum, presented by Dr Leach.

b. Antennæ with a dorsal seta.

Genus Microdon, Illig. Antennæ porrect, the first joint elongate, cylindrical, the third with a naked dorsal seta at the base: scutellum armed with two teeth: wings incumbent, parallel.

M. *apiformis.* The head and thorax are dark brassy, and shining; the hypostoma is covered with bright yellow pubescence, but on the forehead, thorax, and scutellum it is of a fulvous colour: abdomen black, clothed with shining golden-yellow pile, which forms a narrow band at the hinder margin of the first segment, and a broader one on the second, somewhat interrupted in the middle, and covers nearly the whole of the third and fourth segments: wing-scales and halteres white; wings brownish: thighs black, with ferruginous pile, the tibiæ and tarsi entirely ferruginous. Four to five lines. *Musca apiformis*, Degeer, pl. vii. fig. 18–20; *Musca mutabilis*, Linn.; Curtis, *B. E.* 70.

Meigen describes four European species, but the above is the only one known as British. It has been found in the New Forest, and near Lyndhurst, in Hants, but appears to be scarce in the country, although common in France and many other parts of Europe.

Genus Chrysotoxum, Meig. Antennæ inserted on a frontal tubercle, porrect; first joint cylindric, the rest somewhat compressed, equal, the terminal one with a naked dorsal seta at the base: scutellum unarmed: abdomen margined: wings divaricating.

C. *arcuatum.* Hypostoma shining yellow, with a black line down the middle; the forehead of the females black, with two yellow spots; antennæ black: thorax black, with an interrupted yellow line on each side, and two abbreviated cinereous lines on the back: abdomen without hairs, black, and having four arched interrupted bands of golden yellow; belly with four golden-yellow spots; the wings are yellow at the anterior margin, and behind the middle, near the anterior edge, there is a small brown spot. Five and a half lines. *Syrphus arcuatus*, Fab.; *Musca arcuata*, Linn. This insect occurs not unfrequently throughout the south of Scotland and England during the autumn, frequenting various flowers. We have often taken *C. bicinctum* in company with it, on the flowers of *Senecio Jacobæa*, in Roxburghshire. The species have a *waspish* look, from their prevailing hues of black and yellow. They feed on the juices of flowers. Their flight is rapid.

Genus Psarus, Fab. Antennæ inserted on a common peduncle, porrect, the radical joint cylindrical, second elongate and compressed, third oblong and compressed, with a naked seta placed on the middle of the back: wings incumbent, parallel.

P. *abdominalis.* Hypostoma black, with a grey play of colour on the sides; forehead black, with two white spots: thorax black and naked: scutellum semicircular and unarmed: abdomen naked, nearly linear, reddish brown; the base and apex black, sometimes having a black line along the back: wing-scales and halteres white: thighs black; tibiæ and tarsi inclining to brown. Four lines. *Syrphus abdominalis*, Fab.; *Psarus abdominalis*, Lat. Appears to be a rare and little-known species. Specimens found in this country are preserved in the British Museum.

Genus Paragus, Lat. Antennæ with the two basal joints equal, the third elongate, compressed, with a naked dorsal seta before the middle: hypostoma somewhat convex, smooth: abdomen linear, transversely rugose; the hinder metatarsus somewhat thickened: wings parallel, incumbent.

P. *obscurus*. Female. Antennæ proportionally shorter than in most of the other species, and entirely dark brown: eyes pubescent: thorax with a slight grey play of colour, the sides covered with pubescence of a silvery hue: abdomen shining black: legs yellow; the thighs black, with the apex yellow: halteres white. Two and a half lines. Inhabits France and England.

Genus Ascia, Meg. Antennæ with the third joint oblong, compressed, having a naked dorsal seta before the middle: hypostoma impressed, smooth, produced beneath: abdomen contracted at the base: hinder thighs thickened, and spinose beneath: wings incumbent, parallel.

A. *floralis*. Abdomen black, and marked with two yellow fasciæ, which are entire in the male, and interrupted in the female: anterior legs yellow, the tibiæ with a black ring before the apex; the hinder legs black, with a metallic lustre, the thighs yellow at the base, the tibiæ yellow, with a black band in the middle, and the tarsi black: wings hyaline. Two and a half lines.

Found occasionally in gardens and fields in the southern counties of Scotland, and in England.

Genus Sphegina, Meig. Antennæ with the terminal joint orbiculate, compressed, with a naked dorsal seta at the base: hypostoma impressed, smooth: abdomen contracted at the base: hinder thighs clavate, spinose beneath: wings parallel, incumbent. Meig. iii. 193.

S. *nigra*. Hypostoma whitish; antennæ rufous-brown: thorax and abdomen shining black, the former with a greenish tint: halteres yellowish white: the four anterior legs pale yellow; thighs of the hinder pair black, yellow at the base; the tibiæ with two brown bands; tarsi black. Three to three and a half lines. Two species only belong to this genus, both of which are to be found in Britain. Mr Duncan took a few examples of the above in the neighbourhood of Edinburgh in the summer of 1830. The other species, *S. clunipes* (Meig. pl. xxviii. f. 5) is of more frequent occurrence.

Genus Baccha, Fab. Antennæ with the third joint sub-orbicular, compressed, having a naked dorsal seta at the base: hypostoma tuberculated: abdomen elongate, attenuated before, and clavate behind: legs simple: wings parallel and incumbent.

B. *nigripennis*. Antennæ brown: thorax dark brassy, the abdomen inclining to golden green, and flat behind; at the base of the third segment there is a scarcely perceptible yellow spot on each side, and a yellow band on the fourth: anterior legs yellow; the hinder ones brownish, with the base of the thighs yellow: wings blackish. Three lines. Found in Austria by M. Megerle. It likewise occurs in Britain, along with six other species—nearly the whole that the genus contains.

Genus Eumerus, Meig. Antennæ with the third joint orbicular, compressed, and having a naked dorsal seta before the middle: hypostoma sub-convex, villose, smooth: hinder thighs thickened, and spinose beneath: wings incumbent, parallel.

E. *grandis*. Hypostoma covered with whitish pubescence; forehead of the males similar, that of the female black, with white pubescence under the eyes: antennæ dark brown: thorax dark brassy, with two whitish lines anteriorly, the sides somewhat shining: abdomen black, the sides testaceous, and adorned with three pair of crescent-shaped spots: legs dark metallic green, the tibiæ and tarsi with ferruginous pubescence: halteres brown: wing-scales white; wings grey. Five lines. Meig. *Zw.* iii. pl. xxviii. f. 18. Five species of Eumeri are found in this country: *E. ruficornis*, *ornatus*, *strigatus*, *funeralis*, and *silene*. The one described above occurs on the continent.

Genus Xylota, Meig. Antennæ inserted on a frontal tubercle, nutant, the third joint sub-orbicular, compressed, with a naked dorsal seta at the base: hypostoma impressed, blunt below, smooth, or somewhat tuberculated: hinder thighs thickened, and spinose beneath: wings incumbent, parallel.

X. *sylvarum*. Hypostoma yellowish white, and finely pubescent, the forehead similar in the male, but in the female shining black, with two white spots anteriorly: antennæ brown: thorax dark metallic green, with a grey spot on each shoulder; the pubescence on the sides golden yellow: scutellum dark green: abdomen black, the two first segments thinly clothed with golden pubescence; similar pubescence covers the base and sides of the third, leaving a triangular black spot behind, and the fourth segment is entirely covered with it; fifth segment minute and shining black: wing-scales and halteres yellowish white: wings brownish, with a ferruginous stigma: legs ferruginous, the thighs and two last tarsal joints black; hinder thighs club-shaped, and armed with small prickles; tibiæ crooked, and having a brown play of colour behind. Six lines. *Musca sylvarum*, Linn.; *Syrphus sylvarum*, Fab.; *Milesia sylvarum*, Lat. Found occasionally in various parts of the continent. We have taken single specimens near Edinburgh, and in the neighbourhood of Jedburgh. *X. segnis*, and *pipiens*, are comparatively common in England and the south of Scotland. The former is often plentiful at Roslyn. The larva of this genus, described by Degeer, was found in the dung of horses.

Genus Milesia, Fab. Antennæ inserted on a frontal tubercle, the third joint lenticular, with a naked dorsal seta at the base; hypostoma impressed, smooth, or slightly tuberculated; legs simple, the hinder tibiæ compressed; wings incumbent, parallel, the intermediate transverse nerve oblique.

M. *speciosa*. Hypostoma and forehead ferruginous, with a yellowish-white play of colour on the sides; the crown black: antennæ ferruginous: thorax dark brassy green, finely pubescent, blackish on the sides, and yellow on the shoulders: abdomen dark brassy, cylindrical, and finely pubescent; having a line along the back, and the hinder margin of the segments covered with shining golden-yellow pubescence, and before this yellow edging there is a transverse band of black: wing-scales white: halteres bright yellow: wings brownish yellow along the anterior margin, but before the apex this colour passes into brown: thighs dark brown, with a ferruginous spot at the apex; tibiæ and tarsi ferruginous. Seven lines. Found, according to Meigen, near Paris, and likewise in Austria and Italy. "It is now several years," says Mr Curtis, who has given a beautiful representation of this insect in his *Brit. Entom.* fol. 34, "since this fine and rare insect was discovered in the New Forest by Mr D. Bydder, and the beginning of June of the present year (1824) I took four near Brockenhurst: they appear to delight in settling in the thickest parts of the Forest, where a partial shadow is thrown by the surrounding foliage upon the trunks of trees, or the flat surface remaining when they have been felled."

Genus Pipiza, Meig. Antennæ nutant, the third joint ovate and compressed, having a naked dorsal seta at the base: hypostoma smooth: hinder thighs somewhat thickened: abdomen oblong-elliptical: wings parallel, incumbent.

P. *Artemis.* Black, with whitish hair: the second segment of the abdomen with a lunate fascia of a red colour: thighs black, tibiæ ferruginous anteriorly, brown behind; tarsi ferruginous: halteres bright yellow: wing-scales white; outer half of the wings brown, the colour becoming paler at the apex: belly black, yellow anteriorly. Three lines. Inhabits Austria and England. There are fifteen British species of this genus, and twenty-nine are indigenous to Europe.

Genus Psilota, Meig. Antennæ nutant, the terminal joint oblong-ovate, with a naked dorsal seta at the base: hypostoma impressed, truncated beneath: eyes hirsute: wings incumbent, parallel.

P. *anthracina.* Hypostoma and forehead bluish black; the body of a similar colour, and covered with very short pubescence; abdomen oval: legs black, the thighs all straight; the tarsi with fine ferruginous pubescence; the hinder legs somewhat elongate, and the tibiæ a little bent: wing-scales and halteres white; wings hyaline, somewhat yellowish at the base, and the stigma bright yellow. Three lines. Meig. *Zw.* iii. pl. xxix. f. 20. Found in Germany and Britain.

Genus Rhingia, Fab. Antennæ porrect, nutant, the third joint lenticular, the base with a naked dorsal seta: hypostoma somewhat impressed, elongate beneath, conical: wings incumbent, parallel. Meig. iii. 257; Lat. *Gen. Crust.* iv. 320.

R. *rostrata.* Hypostoma and rostrum ferruginous, shining, the latter brown at the tip; antennæ ferruginous; forehead of the females grey, with a dark streak: thorax grey, with three black-brown lines; scutellum shining, brownish yellow: abdomen ferruginous, the basal segment sometimes blackish, and a longitudinal brown line on the second: legs ferruginous, the hinder tarsi brownish: wing-scale and halteres light yellow: wings somewhat greyish, yellowish at the anterior margin. Four lines. Meig. iii. 258. *Conops rostrata*, Linn., &c. Common throughout the country. *R. campestris* (Curtis, *B. E.* pl. clxxxii.), which differs from the above chiefly in having the incisures of the abdomen, and a longitudinal dorsal line, of a black colour, is likewise of frequent occurrence, and is probably not specifically distinct. The name of a third species, *R. monostigma*, has been recently published, but we are unacquainted with its characters and history. We have but a slight knowledge of the metamorphoses of these insects. Indeed all that is yet known is inferred from the fact of Réaumur having found *Rhingia rostrata* in the perfect state in a sand-box (*poudrier*) in which he had previously enclosed some cow-dung containing unknown larvæ. The perfect insects occur in gardens and meadows. The species are by no means numerous.

Genus Brachyopa, Hoff. Antennæ inserted on a frontal tubercle, nutant, the terminal joint lenticular, and having a hirsute dorsal seta at the base: hypostoma impressed and elongate beneath, truncated: wings incumbent, parallel, one half longer than the abdomen.

B. *bicolor.* Hypostoma, antennæ, and forehead (of the males) ferruginous, with a white play of colour; forehead of the females grey, with a yellow spot anteriorly: thorax dark grey or lead colour, with three brown lines, of which the central one is double: scutellum rust-brown: abdomen ferruginous, with a black dorsal line on the second segment, which however is sometimes wanting: legs ferruginous, with dark-brown tarsi: wing-scales white: halteres bright yellow: wings unspotted, slightly obscured with brown. Three lines. *Rhingia bicolor,* Fallen. The insects of this genus are found on flowers, but seem to be in general rare. The above, and another species named *B. conica*, are said to have occurred in England.

Genus Chrysogaster, Meig. Antennæ nutant, the third joint compressed, orbiculate, or oblong, having a naked dorsal seta at the base: forehead of the female crenated on both sides: abdomen depressed: wings parallel, incumbent.

C. *ænea.* Shining brassy, except the apex of the abdomen, which is dull black; the belly dark green: antennæ testaceous: wings hyaline, partly of a yellowish-brown colour, with a ferruginous stigma. Three lines. Inhabits Austria and Britain, but seems everywhere rare.

Genus Syrphus, Fab. (Plate CCXXXVIII. figs. 17 and 17 *a.*) Antennæ porrect, nutant, three-jointed; the third joint orbicular or oval, compressed, with a pubescent dorsal seta at the base: hypostoma tuberculated: feet simple, slender: wings incumbent, parallel, the ordinary transverse nerve nearly perpendicular.

S. *Lucorum.* Hypostoma white, with a shining black line down the middle; forehead whitish, having a black spot over the antennæ, and a brown line in the females: antennæ black, with a very finely pubescent seta: thorax black, with reddish-yellow pile; scutellum rufous: abdomen having the first segment whitish, with pubescence of the same colour, the male with a wide dark-coloured vitta; third segment deep black; fourth black, with whitish pubescence and somewhat glossy, especially on the sides: legs dark brown, the base of the tibiæ whitish: halteres and wing-scales brown; wings hyaline, having a dark-brown vitta in the middle of the anterior margin extending half way across. Five lines. Meig. iii. 313, pl. xxx. f. 27. *Musca lucorum*, Linn. Not unfrequent on umbelliferous plants in woods throughout the country. The genus *Syrphus*, as characterized by Meigen, comprehends nearly 100 species, of which upwards of one half, besides a considerable number of others recently discovered, are to be found in Britain. The dissimilarity in form and structure which prevails among many of these insects, has led to their distribution, by later writers, into three generic groups, distinguished by the names *Cheilosia, Scæva, Syrphus;* and they appear to be susceptible of still further subdivision. As the English species are comparatively well known, it may be interesting to mention such as we have ascertained to inhabit Scotland: *S. ostraceus* (frequent), *variabilis, lunulatus, Pyrastri, seleniticus, Ribesii* (common), *balteatus* (common), *cinctus, decorus, umbellatarum, tæniatus, mellitargus, Rosarum, Ocymi, granditarsus* (three last near Edinburgh, not common). The larvæ of the Syrphi prey upon Aphides. Their form is that of an elongated cone. Their segments are very retractile.

Genus Pelecocera, Hoff. Antennæ porrect, the third joint somewhat patelliform, the apex furnished with a thick, short, three-jointed seta: hypostoma arched beneath.

P. *tricincta.* Hypostoma white, with a shining black vitta: thorax black, shining, the shoulders white, and the sides before the base of the wings marked with a white streak: scutellum shining black; abdomen likewise black, with a broad ferruginous band at the base of the second, third, and fourth segments: legs reddish yellow, the hinder pair with a brown ring on the thighs and tibiæ: wing-scales and halteres white: wings somewhat brownish, with a ferruginous stigma. Three lines. Found in some parts of the continent, but everywhere rare.

Genus Sericomyia, Lat. Antennæ porrect, nutant, the third joint patelliform; the base with a plumose dorsal seta: hypostoma descending, tuberculated: wings parallel, incumbent, hirsute.

S. *borealis.* Hypostoma ochreous, with a black line; antennæ dark brown; forehead of the males yellow, of the females black brown: thorax black, with a tuft of whitish pubescence on each shoulder, and golden-yellow pubescence on each side before the base of the wing: scutellum blackish brown: abdomen black, with four ochreous bands, the first, and sometimes the second also, somewhat interrupted; belly dull ochreous, brown at the base: legs rufous, base of the thighs black: wing-scales yellow: halteres brown: wings hyaline, with the anterior margin yellowish, and sometimes with a pale-brown tinge before the apex. Seven lines. *Syrphus borealis*, Fallen; *Musca lappona*, Degeer. Abundant in some parts of the south of Scotland during the autumnal months, and frequently seen on the flowers of *Senecio Jacobæa*, in company with numerous species of the genus *Eristalis.* Its appropriate locality seems to be elevated pasture lands, and the sides and summits of hills. In the latter situation we have occasionally heard it, in fine weather, emit a peculiarly shrill and stridulent note, which is sufficiently loud to be heard at a considerable distance. A nearly allied species, *S. lappona*, Linn., occurs among the Pentland Hills, near Edinburgh.

GENUS TROPIDIA, Meig. Antennæ nutant, third joint patelliform, with a naked dorsal seta: hypostoma carinated, smooth: hinder thighs thickened, with a single tooth at the apex beneath: wings parallel, incumbent, hirsute.

T. *fasciata.* Hypostoma greyish white, with a black longitudinal line, and covered with fine silky hairs; antennæ rufous: thorax with yellow pubescence, of a dark green, somewhat metallic, with two whitish abbreviated lines on the back, and a spot on each shoulder: abdomen with ferruginous pubescence, of a dark brown, and having a rufous interrupted band on the second, third, and fourth segments: thighs of the anterior legs blackish, the apex rufescent, the tibiæ and tarsi rufous, with a brown apex: hinder thighs blackish, the tibiæ crooked, reddish at the base, the other parts, as well as the tarsi, brown: halteres and wing-scales white: wings hyaline. Four lines. Found in some parts of the continent on *Achillæa ptarmica*, in the neighbourhood of Paris, and in Austria. The only other species described by Meigen, *T. milesiformis*, has been found in Britain, along with another, named *T. rufomaculata* (Curtis), which does not appear to be known to continental naturalists.

GENUS MERODON, Fab. Antennæ nutant, the terminal joint oblong or elliptical, compressed, with a naked dorsal seta at the base; hypostoma smooth and villose: hinder thighs thickened, with a single tooth at the apex beneath: wings incumbent, parallel, hirsute.

M. *equestris.* Male. Hypostoma and forehead with greyish white pubescence; antennæ black: thorax anteriorly dark brassy, with ferruginous pile, shining black behind, with pile of the same colour: scutellum and abdomen coloured and clothed like the anterior part of the thorax: legs black, the anterior tibiæ and tarsi with ferruginous silky hairs; the hinder tibiæ with a tubercle on the inner side behind the middle, and a hooked spine at the end: halteres brown: wings nearly hyaline. Six lines. *Syrphus equestris*, Fab. Réaumur, *Ins.* iv. tab. xxxiv. fig. 9, 10. This species has occurred in Italy and near Paris. *M. clavipes* is the only British species known. It is figured and described in Curtis' *B. E.* fol. xcviii.

GENUS HELOPHILUS, Meig. Antennæ porrect, nutant, the terminal joint patelliform, the base with a naked dorsal seta: hypostoma descending, gibbous beneath: eyes naked: hinder thighs thickened, unarmed: wings divaricating, hirsute.

H. *pendulus.* Hypostoma yellowish white, with a shining black vitta in both sexes; forehead whitish yellow, the crown dark brown, and a small black spot over the antennæ; the latter dark brown, with a yellow seta: thorax straw colour, with three black vittæ: scutellum shining brownish yellow: abdomen deep black, with three unequal interrupted yellow bands: the belly pale anteriorly, the three last segments black, with white incisures: wing-scales and halteres yellow; anterior legs rufous, nearly the whole of the thighs and the tarsi brown; hinder legs dark brown, the apex of the thigh and base of the tibiæ more or less yellow. Five lines. *Syrphus pendulus*, Fab.; *Musca pendula*, Linn.; *Elophilus pendulus*, Lat Everywhere common. The species of this genus do not greatly differ from those of *Eristalis.* They are generally less hairy. Several exhibit the aspect of garden bees, as well as of other Hymenoptera. The larvæ, known under the name of rat-tailed worms (*vers à queue de rats*, Réaumur),[1] are remarkable for the great length and singular uses of their caudal extremity. It serves as a respiratory organ. The insect lies at the bottom of stagnant waters, generally concealed in the mud; but the point of its attenuated tail is meanwhile in contact with the surface. Réaumur found, by increasing the depth of water, that the larva could extend its respiratory tube to the height of five inches. After that, however, it was seen to leave the mud, and ascend the side of the vessel in which it was contained, that it might attain to the surface with greater ease. The tail seems composed of two parts, one of which slips into the other like the portions of a telescope. They are composed of annular fibres, and when these are contracted, each tube is greatly increased in length.

GENUS MALLOTA, Meig. Antennæ nutant, third joint nearly four-angled, compressed, with a naked dorsal seta in the middle: hypostoma descending, gibbous: wings divaricating, hirsute.

M. *megilliformis.* Male. Hypostoma black, thickly covered with silken hairs of a pearl-grey colour, and having a naked shining black vitta; forehead black, pearly on the sides beneath; the hinder part of the head with ferruginous pile; antennæ black, the third joint with a white seta: thorax and abdomen dark green, thickly clothed with ferruginous hair; belly and legs black; wing-scales ferruginous; halteres also ferruginous, with the knob brown: wings nearly hyaline, with brown nervures. Six lines. Rare: The females have not been described. The genus contains only three species, none of which appear to be British.

GENUS ERISTALIS, Fab. Antennæ porrect, nutant, three-jointed; the third joint patelliform, with a plumose or naked seta at the base: hypostoma elongate, tuberculated: legs simple: wings spreading, naked (in the greater number of species).

E. *intricarius.* Male. Hypostoma and forehead black, with yellowish-white hair; antennæ black at the base, the third joint rufous, with a plumose seta of the same colour at the base: thorax black, thickly clothed with reddish-yellow hair; scutellum yellow: abdomen black, with ferruginous lateral spots, and clothed anteriorly with ferruginous hair, which on the hinder parts passes into a whitish-yellow colour: wing-scales blackish: wings hyaline, the central cross nerve more or less distinctly margined with brown: legs black, the apex of the thighs and basal half of the tibiæ white. Six lines. Meig. iii. 391. *Syrphus intricarius*, Fab.; *Musca intricaria.* Linn. Of frequent occurrence during summer on flowers and plants. Several species of this extensive genus are very common in this country, particularly *E. tenax, similis, horticola*, &c. About a score inhabit Britain. The larva of *E. narcissi* (which inhabits the bulb of the plant from which it derives its name) is figured and described by Réaumur.[1]

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[1] *Mémoires*, t. iv. p. 442.

GENUS VOLUCELLA, Geoff. Antennæ decumbent, the third joint elongate, compressed, with a long plumose dorsal seta at the base: hypostoma impressed above, elongate beneath, conical, gibbous: wings divaricating. Meig. iii. 401; Lat. *Gen. Crust.* iv. 322.

V. *pellucens.* Hypostoma, forehead, and antennæ shining ferruginous, the latter with a black plume: thorax shining black, bristly: scutellum testaceous brown, sometimes black,[2] bristly: abdomen pubescent, shining black, the second segment yellowish white, pellucid, having a central line of black in the males, but usually uninterrupted in the females, except by a very faint black line; belly like the back, except the anterior part of the third segment, which is likewise transparent: legs black: wing-scales yellowish: halteres with a blackish stalk, the knob white: wings yellowish at the base, with ochreous veins, the rest greyish, with brown veins. Seven lines. Meig. iii. 405. *Musca pellucens*, Linn. An insect of not unfrequent occurrence in Britain during the summer months, frequenting flowers in sheltered situations exposed to the sun. In the summer of 1829 it appeared in unusual abundance in the fields adjoining Duddingston wood, near Edinburgh. All the other species belonging to the genus (as now restricted) are to be found in Britain, with the exception of *V. zonaria* (Meig. iii. pl. xxxii. f. 27). The most common in Scotland next to the species described is *V. plumata*, which is found occasionally throughout the southern counties. *V. bombylans* appears to be considerably scarcer; the only examples which we have met with were from Dumfriesshire and East Lothian. The larvæ of these insects inhabit the nests of wasps and bees, and live at the expense of the proper owners. Réaumur has detailed their history at great length, and in a very interesting manner. "Lepelletier de Saint Fargeau a eu occasion d'observer que les volucelles de diverses espèces s'accouplent trés-bien ensemble; il a lu un Mémoire à ce sujet à l'Académie des Sciences."[3]

FAMILY XV.—PLATYPEZINÆ.

Antennæ porrect, two or three-jointed, with a naked apical seta: proboscis concealed; thorax without a transverse suture: abdomen with six segments: wings incumbent: the small cross nerve of the middle bent towards the base: halteres naked.

GENUS CYRTOMA, Meig. Antennæ approximating, two-jointed, first joint small, cylindric; second elongate, conic, compressed, the apex with a two-jointed style: proboscis subporrect: hinder legs elongate: wings incumbent, parallel. Meig. iv. 1.

C. *nigra.* Black; halteres yellow; the legs brown; the hinder tibiæ club-shaped, the lowest joint of the tarsi thickened; wings somewhat brownish. Two lines. Found in Germany and elsewhere occasionally. This genus contains three species, none of which are known to inhabit Britain.

GENUS PLATYPEZA, Meig.; name derived from πλατυς, *broad*, and πεζα, *the foot.* Antennæ straight, approximating, three-jointed, the lower joints sub-cylindric, third ovate, compressed, the apex with a three-jointed naked seta: proboscis concealed: hinder feet thickest, tarsi dilated, the joints nearly equal: wings incumbent, parallel.

P. *boletina.* Male. Velvet black; abdomen with greyish-black bands: legs brown: halteres black brown: wings hyaline.

Female. Clear ash-grey, abdomen with a narrow deep black cross band, somewhat widened in the middle, before the incisures; the first segment without a band: halteres and legs bright yellow: wings hyaline. One and a half line. Fallen. Occurs in Germany and England, rare.

GENUS CALLOMYIA, Meig. (Plate CCXXXVIII. figs. 18 and 18 *a.*) Generic name from καλος, *beautiful*, and μυια, *a fly.* Antennæ straight, three-jointed; the lower joints sub-cylindric, third compressed, acute; the terminal seta elongate, three-jointed: proboscis concealed: hinder legs elongate, thick, the metatarsus elongate: wings incumbent, parallel.

C. *amœna.* Male. Body velvet black: halteres rufous: fore legs honey-yellow, the thighs blackish brown: hinder legs entirely black brown: wings hyaline.

Female. Hypostoma and forehead bright blue: thorax bright blue on the sides, with a silvery lustre: this colour extends forwards along the thorax in the form of a bow, and before the scutellum there is likewise a silvery band: scutellum black: abdomen with the three first segments orange yellow, the fourth and sixth deep black, the fifth silvery blue, with a black line on the middle; fore legs rufous; hinder legs black, with rufescent thighs: halteres rufous: wings hyaline. Two lines. Meig. *Zw.* iv. pl. i. f. 13. This species has been recently taken in England.

FAMILY XVI.—MEGACEPHALI.

Antennæ three-jointed; the third joint deflexed, with an erect seta at the base: hypostoma linear, narrow: proboscis concealed: abdomen consisting of six segments: wings incumbent; the short transverse nervure in the middle: halteres naked.

GENUS PIPUNCULUS, Lat. (Plate CCXXXVIII. figs. 19 and 19 *a.*) Antennæ triarticulate; first joint minute, second cup-shaped, third deflexed, acute, compressed, with an erect naked seta at the base: hypostoma narrow, linear: proboscis concealed: wings incumbent, parallel. Meig. *Zw.* iv. 18, pl. xxxiii. f. 15–24.

P. *spurius.* Deep velvet black, the apex of the abdomen somewhat shining: hypostoma silver white, changing, with a play of colour, into black: forehead very narrow, black, silver white above the antennæ: the latter, together with the legs, black: wings brownish, with a dark-coloured stigma. One line. Meig. *Zw.* iv. pl. xxxiii. f. 24. Occurs in England, but is rare.

FAMILY XVII.—DOLICHOPODES.

Antennæ porrect, three jointed: the third joint flat, with an apical or dorsal seta: hypostoma linear: proboscis somewhat exserted, with compressed incumbent palpi: thorax without a transverse suture: abdomen consisting of six segments: wings incumbent; the short transverse nerve bent towards the base: halteres naked.

GENUS RHAPHIUM, Meig. Antennæ approximating, the third elongate, compressed, with a two-jointed style at the apex: eyes separated: wings incumbent, parallel.

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[1] *Mémoire*, t. iv. p. 499, and pl. xxxiv.

[2] The scutellum is usually ferruginous when the insect issues from the chrysalis, but becomes darker as it advances to maturity, till it ultimately acquire the colour of the thorax.

[3] *Diction. Class. d'Hist. Nat.* t. xvi. p. 631.

R. *vitripenne.* Hypostoma bluish white; forehead shining steel blue: antennæ black, slender, those of the male as long as the abdomen, those of the female much shorter; the body dark metallic green, legs black, the anterior tibiæ brown; halteres white: wings hyaline. Three lines. Meig. *Zw.* iv. pl. xxxiii. f. 4. Four species of this genus, nearly half the number known, have been found in Britain. The species described occurs on the continent.

Genus Diaphorus, Meig. Antennæ with the third joint patelliform, having a villose dorsal seta: eyes meeting on the forehead; abdomen of the male with two filiform appendages on the under side of the apex: wings incumbent, parallel. Meig. *Zw.* iv. pl. xxxiv. f. 6–9.

D. *flavocinctus.* Hypostoma white; antennæ black: body black, with greenish reflections; the second segment of the abdomen, and sometimes the base of the third, ferruginous, transparent: anterior legs rufous, with blackish thighs, rufescent at the apex on the under side: middle pair of legs rufous, the basal half of the thighs black: hinder legs black, the upper half of the tibiæ rufous: halteres white: wings reddish brown. One and a half line. Meig. *Zw.* iv. pl. xxxiv. f. 8. Inhabits England, but is not common.

Genus Psilopus, Meg. Antennæ with the third joint patelliform, villose; furnished with an inclined villose dorsal seta before the apex: eyes separated: wings incumbent, parallel, the transverse nerve at the apex curved.

P. *platypterus.* Male. Head white: antennæ pale yellow; the third joint brown: palpi white: thorax cinereous-green, with a faint metallic lustre: abdomen brassy, the apical segment blackish: legs long, pale yellow: halteres yellow: wings very broad, hyaline.

Female. Hypostoma somewhat wider than in the male: legs pale yellow, with brownish tarsi. Two and a half lines; the females rather less. This and seven other species of Psilopi are found in Britain, but none of them appear to be frequent.

Genus Chrysotus, Meig.; named from χϱυσοτος, *gold colour*, bright golden green being the prevailing colour of the species.—Antennæ with the terminal joint patelliform, villose, having an inclined villose seta at the apex: eyes separated: abdomen of the male with two filiform appendages at the apex beneath: wings incumbent, somewhat spreading. Meig. iv. 40, pl. xxxv. f. 7–11.

C. *neglectus.* Hypostoma of the males minute, blackish; that of the female wider and of a whitish colour; eyes of a beautiful golden green, with light-blue reflections: forehead metallic green: body bright golden green; legs straw yellow, with dark-brown tarsi, which are yellowish at the base: halteres white: wings hyaline, with a play of colour: the terminal segment of the abdomen small, lying in a cavity of the belly, with two short threads at its extremity. Meig. *Zw.* pl. xxxv. f. 10. Found in Britain, with seven other species, all that are known to belong to the genus.

Genus Porphyrops, Meig. (Plate CCXXXVIII. figs. 20 and 20 *a.*) Generic name compounded of πoϱφυϱα, *purple*, and οψ, *the eye*. Antennæ with the terminal joint oblong, acute, the seta villose and bent downwards: eyes separated: abdomen of the male with two filiform appendages at the apex beneath: wings incumbent, parallel. Meig. *Zw.* iv. pl. xxxv. f. 1–6.

P. *diaphanus.* Male. Hypostoma narrow and black; antennæ black; forehead black above, shining white beneath: thorax metallic black with green reflections, and having a long mark of changeable white on the sides anteriorly: abdomen conical, bluish, with a silvery lustre, viewed in another direction dark slate grey; with two interrupted reddish-yellow diaphanous bands on the second and third segments: legs dark brown, with ferruginous tibiæ which are brown behind: halteres white: wings vitreous. Three lines. *Musca diaphana*, Fab. Gmel.

The female has the thorax bright golden green with light-blue reflections; the abdomen more silvery than the male; and besides the two fasciæ, there is a yellowish spot on each side of the fourth segment: the anterior thighs are yellow at the apex. Inhabits England, and is not unfrequent in woods in the south of Scotland. Twenty-nine species have been described, ten of which are ascertained to inhabit Britain. All of them are minute insects, several being only a line in length, and none exceeding the size of the species described above. They are remarkable for beauty of colouring, which generally consists of changeable tints of metallic green, blue, and silver white. This circumstance, together with the activity of their motions, by which their colours are continually presented under varying lights, renders them more observable objects, in the shade and among the foliage of woods, where they usually prevail, than might be inferred from the smallness of their size.

Genus Medeterus, Fischer. Antennæ with the terminal joint short, sub-ovate, compressed, with a two-jointed dorsal seta: eyes separated: abdomen of the male with two filets at the apex: legs elongate, slender: wings incumbent, parallel. Meig. *Zw.* iv. pl. xxxv. f. 12–17.

M. *regius.* Male. Hypostoma and palpi white: antennæ black: forehead cinereous, with a greenish lustre: thorax dark green, with a greyish patch over the middle, in which are two blackish approximating longitudinal lines: sides of the thorax cinereous: abdomen sea-green, the hinder margin of the segments with a blackish band, bordered anteriorly with grass green: legs dark green: halteres white: wings hyaline, with a brown spot behind the middle, and the anterior margin from the middle to the apex more or less dusky, the apex itself with a white spot encircled with brown.

Female. Hypostoma black, steel-blue beneath; palpi greyish black margined with white: wings hyaline, with only the brown spot, the other markings wanting. Three lines. Found in France, Holland, Austria, and England.

Genus Sybistroma, Meg. Antennæ with the terminal joint oblong, compressed, having an elongate two-jointed seta on the back, the first joint longest; eyes separated: abdomen of the male incurved at the apex, and furnished with two flat ciliated processes. Meig. *Zw.* iv. pl. xxxiv. f. 18–20.

S. *patellipes.* Male. Hypostoma rather wide, white; forehead whitish with a metallic lustre: antennæ with the two basal joints black, the third ferruginous: body obscure brassy: legs yellow, the anterior tarsi of the male orbicular, and of a black colour: halteres white; wings brown. Two and a half lines. Communicated to Meigen by Dr Leach, who found the insect in England.

Genus Dolichopus, Lat. Antennæ with the third joint trigonate, compressed; the dorsal seta pubescent: eyes separated: abdomen of the male with the apex incurved, and furnished with two membranous ciliated lamellæ: wings incumbent, parallel.

D. *ungulatus.* Hypostoma silver white, rather wide in the female, and having a protuberance on each side beneath: palpi blackish: antennæ black: forehead, thorax, and abdomen brassy green: sides of the thorax slate-grey: coxæ greyish black, the anterior pair rufous beneath: abdomen bluish grey with a play of colour, the incisures and a line on the back black: legs rufous: apex of the hinder tibiæ, and all the tarsi, black: wings slightly cinereous: halteres yellowish white: anal segment of the abdomen in the males black, with bright yellow lamellæ which are edged with black. Three lines in length. Lat. *Musca angulata*, Linn.; *Nemotelus æneus*, Degeer, *Ins.* vi. 78, 15, pl. xi. f. 14–22. Found in England, the south of Scotland, and various parts of the continent. The genus contains upwards of fifty species, none of them much exceeding three lines in length; nearly the half inhabit Britain. The larva of the one above mentioned is described by Degeer. He found it under ground in the month of May. It is white, cylindrical, eight lines in length, with a pointed or conical anterior. The head varies in form, being often sunk into the first segment. On the fourth of June it became a nymph, of a much shorter and thicker shape than the larva. It was then very restless, rolling about incessantly, with a constant movement of the abdomen. The perfect insect appeared on the 27th of the same month.

Genus Orthochile, Lat. Antennæ porrect, the third or terminal joint compressed, sub-orbiculate, and having a dorsal seta: proboscis exserted, perpendicular, with acute incumbent palpi: wings incumbent, parallel.

O. *nigrocærulea*. Thorax shining blue black, the sides of the breast slate-grey: abdomen dark metallic green; the anal segment in the males shining black: coxæ slate-grey; the thighs black, with a ferruginous apex: tibiæ rufous, the hinder pair with the half next the apex black; tarsi black: wings brown. One line. Meig. *Zw.* pl. xxxvi. fig. 5. Found in France and Germany.

FAMILY XVIII.—OCYPTERÆ.

Antennæ porrect, three-jointed: abdomen consisting of six segments: wings without a transverse nervure, pointed: proboscis concealed.

Genus Lonchoptera, Meig. (Plate CCXXXVIII. figs. 21 and 21 *a*.) Antennæ with the basal joint thickened at the apex, second cup-shaped, third sub-orbicular, compressed, with an elongate three-jointed villose seta at the apex: proboscis retracted: abdomen linear, elongate: wings lanceolate, incumbent, without transverse nervures. Meig. *Zw.* iv. pl. xxxvi. f. 6–13.

L. *tristis*. Forehead dusky black; wings smoke colour: under side of the head yellow: thorax shining black, the sides yellow: abdomen black, the terminal segment of the males with yellowish lamellæ: legs yellow; the hinder tibiæ somewhat clavate, stouter in the male than in the other sex: halteres white. Has been taken by Dr Leach in England, and occurs in the vicinity of London. *L. lutea*, known by its yellow colour, and a narrow black line along the whole length of the back, has recently been observed in Dumfriesshire and some other southern counties of Scotland.

FAMILY XIX.—SCENOPINII.

Antennæ deflexed, three-jointed; the third joint truncated and without bristles: proboscis concealed: abdomen consisting of eight segments.

Genus Scenopinus, Lat. (Plate CCXXXVIII. figs. 22 and 22 *a*.) Antennæ sub-deflexed, three-jointed, the lower joints small, third elongate, sub-cylindric, truncated, without a seta: proboscis retracted and concealed: abdomen linear, flat, eight-ringed: wings incumbent, parallel.

S. *vitripennis*. Head glossy black: body black; thorax with a faint metallic lustre: halteres brown: head white beneath: legs yellowish red: wings hyaline. One and a half line. Not common. Near Moffat.

FAMILY XX.—CONOPSARIÆ.

Antennæ porrect, three-jointed, angular at the base proboscis porrect, geniculated: thorax without a transverse suture: abdomen consisting of five or six segments halteres naked: wings incumbent. Meig. *Zw.* iv. xi.

Genus Conops, Linn. (Plate CCXXXVIII. figs. 23 and 23 *a*.) Antennæ approximating, the first joint cylindric, second and third clavate, the apex with a two-jointed style: proboscis standing out, filiform, geniculated at the base: ocelli wanting: wings incumbent, parallel.

C. *flavipes*. Antennæ black; head rufous, with a reddish-brown inflated vesicle on the crown, in front of which there is a black line; from this a black vitta extends to the antennæ, where it becomes wider, but does not reach the margin of the eyes: thorax deep black, with a yellow spot on each shoulder, and another on each side behind under the base of the wing: scutellum black, margined with yellow: abdomen sub-cylindric, slightly clavate behind, black; the second and third segments in the male, and the fourth also in the female, with a bright yellow band behind; the basal segment with a yellow spot on each side; the two terminal ones ash-grey: halteres rufous: legs yellow; thighs black, yellow at the base; apex of the tarsi brown: wings with the anterior margin more or less brownish. Five lines. *C. flavipes*, Linn.; *C. macrocephala*, *Samou. Comp.* pl. ix. fig. 8. Upwards of twenty species have been described as belonging to this genus, only six of which have been ascertained to inhabit Britain. They are usually found on flowers, and seldom occur in large numbers. The individual described is found not unfrequently in the south of England, and occurs sparingly during the autumn in Roxburghshire, and the neighbourhood of Edinburgh, generally on the flowers of *Senecio Jacobæa*.

Con. melanocephala of one of Meigen's earlier works was merely a specimen of the above in which the head had become black.

It appears that the females of these insects deposit their eggs in the larvæ of humble-bees (*Bombus*), or even in the bodies of the perfect insects. Latreille, indeed, has frequently observed them issue from the abdomen of the latter. MM. Lachat and Audouin presented a memoir to the *Société Philomatique*, on an apodal larva which they found in the month of July, in the interior of *Bombus lapidarius*, and which they deemed the larva of *Conops flavipes*.[1] Bosc seems to have also noticed this parasite, but he mistook it for an intestinal worm properly so called.[2]

Genus Zodion, Lat. Antennæ with the basal joint cylindric, second clavate, compressed at the base, third ovate, the back with a style: ocelli three: proboscis standing out, filiform, elongate, geniculated at the base: wings parallel, incumbent.

Z. *cinereum*. Hypostoma pale reddish yellow, the margin of the eyes white, the latter colour extending half way up the forehead: forehead reddish yellow anteriorly, passing into dark brown above: antennæ black, the third joint rufescent, with a blackish apex; sometimes the second joint is likewise rufescent anteriorly: thorax cinereous, with four blackish longitudinal lines on the back, of which the two central ones are abbreviated, the sides and hinder part spotted with black: abdomen cinereous,

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[1] See *Mém. de la Soc. d'Hist. Nat.* t. i. p. 330, pl. xxii.

[2] *Diction. Class. d'Hist. Nat.* t. iv. p. 404.

the incisures from the second to the fourth marked with a cross row of elevated black points; the back sometimes with four blackish evanescent spots: anal segment of the males shining black: legs cinereous, the tarsi blackish: wings somewhat brownish, slightly ferruginous at the base. Three lines. Meig. *Zw.* iv. pl. xxxvii. figs. 6, 7; *Myopa cinerea*, Fab.; *Zodion conopsoides*, Lat. Usually found on umbelliferous flowers. It is an inhabitant of England, France, and various parts of the continent of Europe.

GENUS MYOPA, Fab. Antennæ with the basal joint cylindric, second clavate, compressed at the base, third globose, with a dorsal style: ocelli three: proboscis standing out, filiform, elongate, geniculated at the base and middle: wings incumbent, parallel. Meig. *Zw.* iv. 140.

M. *buccata.* Hypostoma white, without spots; forehead dark brown, with grey spots; antennæ testaceous, third joint reddish yellow: thorax spotted with black and cinereous: shoulders testaceous: scutellum dark brown: abdomen testaceous or reddish brown, spotted with grey on the sides: legs testaceous; thighs blackish before the apex: tibiæ with a dark-brown ring at the middle, and another at the apex; tarsi rufous: wing-scales white: halteres pale yellow; wings clouded with pale brown, the small cross nervure not darker coloured. Meig. iv. 142. *Conops buccata*, Linn. Occurs at times on umbelliferous flowers, in gardens and fields, throughout England and the south of Scotland. Botanic Garden, Edinburgh. *M. picta*, which does not differ much from the above, is likewise found in similar situations near Edinburgh.

FAMILY XXI.—STOMOXIDÆ.

Antennæ deflexed, three-jointed, obtuse beneath: third joint with a dorsal seta: proboscis porrect, geniculated: abdomen consisting of four segments: halteres covered with a double wing-scale. Meig. *Zw.* iv. xi.

GENUS SIPHONA, Meig. Antennæ with the lower joints small; third elongate, linear, obtuse; the base with a naked dorsal seta: proboscis exserted, horizontal, filiform, geniculated at the base and middle: wings divaricating. Meig. *Zw.* iv. 154.

S. *tachinaria.* Thorax and scutellum pale cinereous; the abdomen nearly conical, pale ferruginous; the first and second segments pellucid at the sides, the incisures whitish, with small wart-like spots: thorax, scutellum, and abdomen of the females likewise pale ferruginous; the latter elliptical, and the sides not so clearly pellucid; legs ferruginous, with brown tarsi. Two lines. Meig. *Zw.* pl. xxxvii. fig. 25; *Stomoxys cristata*, Fab. Inhabits Europe. Has been found in England, but is very scarce.

GENUS STOMOXYS, Fab. (Plate CCXXXVIII. figs. 27 and 27 *a*); from στομα, *the mouth*, and οξυς, *sharp.* Antennæ incumbent, with the lower joints small; third elongate, compressed, linear, obtuse, with a dorsal seta at the base; proboscis standing out, horizontal, geniculated at the base; wings divaricating.

S. *calcitrans.* Hypostoma yellowish white: proboscis stiff, porrect, shining black beneath, with filiform, short, ferruginous palpi: forehead wide with a black line, somewhat narrower in the males than in the females: antennæ brown, with a seta which is plumose on one side: thorax cinereous, with short hairs and a black line along the back: abdomen rounded, covered with short hairs, cinereous, with shining black spots: legs black brown: wing-scales white: wings uncoloured. Three lines. *Conops calcitrans*, Linn.; Degeer, *Ins.* vi. 39, 11; *Musca pungens*, pl. iv. fig. 12–18. Not unfrequent throughout Britain. This is the common well-known stinging-fly, which, in hot and sultry summer days, persecutes men and beasts with its painful bite. It attacks the legs in preference to any other part of the body. Even horses and cattle are not protected by their thicker hides. It is said to be most annoying before a storm. The *C. calcitrans* is so like a common house-fly, as to have induced the erroneous belief that the latter is also a blood-sucker. The females lay their eggs in dunghills. According to the observations of MM. Lepelletier and Serville (*Encyclop. Méth.*), many individuals survive the winter in a state of torpidity,—twenty having been sometimes found together in a mass, within the hollow of a tree.

FAMILY XXII.—ŒSTRACIDES.

Antennæ small, three-jointed; the third joint with a naked seta: mouth closed up, without a distinct proboscis: abdomen pubescent, consisting of four or five segments. Meig. *Zw.* iv. xi.

GENUS ŒSTRUS, Linn. (Plate CCXXXVIII. figs. 24 and 24 *a.*) Antennæ with the lower joints minute, the third globose, with a naked seta: mouth closed:[1] halteres covered: wings spreading, the apex with a transverse nervure.

Œ. *ovis.* Hypostoma flesh red: forehead dusky red, with a reddish line, and blackish depressions: antennæ black: thorax cinereous, sprinkled with small blackish warts, each of which supports a fine hair; on the neck these warts form lines: scutellum pale brown, with blackish warts placed without order: abdomen arched, rounded, obtuse, silky white, with a yellowish play of colour in some places, and prettily sprinkled with irregular spots of a deep shining black: legs pale red: wing-scales large and white: wings clear hyaline, with a blackish transverse nervure at the middle. Five lines. Meig. *Zw.* pl. xxxviii. fig. 16; Linn. Fab.; Réaumur, *Ins.* iv. *Mém.* xii. tab. xxxv. fig. 10–15; Clark, *Linn. Trans.* iii. tab. xxiii. fig. 14–17. Of the nine European species of Œstrus, as now restricted, only three inhabit Britain, viz. the one above described, and *Œ. pictus* (Curtis, *Brit. Ent.* iii. pl. cvi.), and *Bovis*. *Œ. ericetorum* of Dr Leach is not regarded by Meigen as essentially distinct from that last named.

The injury and annoyance which the insects of this genus, familiarly known under the names of breeze, gad-fly, &c. cause to sheep and cattle, render them deserving of our careful consideration. Mr Bracy Clark, to whom we still owe the best account of their economy,[2] procured, about the middle of June, some full-grown larvæ of *Œ. ovis*, from the inside of the cavities of the bone which

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[1] Meigen's expression, *mund geschlossen*, is obscure. It has in fact been doubted whether the insects of this and the following genus had any mouths. Linnæus says, "Os nullum punctis tribus;" but, according to Mr Bracy Clark, when the hairs, which in all the species greatly obscure the oral organs, are removed, two clavated *palpi* are seen, and between the opening of the mouth;—"and by laying open the vesicular or inflated part of the face, the continuation of it is visible in the form of a membranous *haustellum*, which is generally coloured with some dark-brown matter lodging on the inside; though I confess, after repeated dissections, I have not been able to trace this haustellum farther than the inside of the inflated part of the head, where it appears to enlarge and terminate. Fabricius has minutely described labia to the haustellum, and other apparatus to the mouth, which I have not been fortunate in obtaining a sight of. At the same time I cannot help being surprised that he should have overlooked the *palpi*, which he expressly denies the existence of, though tolerably visible even without the aid of glasses." (*Linn. Trans.* vol. iii. p. 322.)

[2] *Observations on the Genus Œstrus, Linn. Trans.* vol. iii. p. 289; see also the author's later work, *An Essay on the Bots of Horses and other Animals*, 4to, 1815. It is quoted and referred to by a recent French writer under the title of "The Bost of Horse!"

supports the horns of the sheep. They were nearly an inch long, of a delicate white colour, flat on the under side, and convex on the upper; having no spines at the divisions of the segments of the body, though provided with tentacula at the smaller end. When young they are entirely white, but as they increase in size their upper side becomes marked with two transverse brown lines on each segment, and some spots become visible upon the sides. They move with considerable quickness, holding with the tentacula as a fixed point, and drawing up the body towards them. There is a broad line of dots on the under surface, which appear as rough points under a microscope, and probably serve both for locomotion, and for exciting such a degree of inflammation in the membrane on which they rest, as to cause the secretion of lymph or pus. Mr Clark has usually found these larvæ in the horns or frontal sinuses, though he has remarked that the membranes of those cavities were scarcely at all inflamed, while those of the maxillary sinuses were highly so. From this he is led to suspect that they inhabit the maxillary sinuses, and crawl, on the death of the animal, towards the horns and frontal sinuses. In common with *Œ. Bovis*, they do not seem confined to any particular season, for young and old are found together at the same time. When full grown they fall through the nostrils, and change to the pupa state, lying on the earth, or adhering by the side to a blade of grass. The fly bursts the shell of the pupa in about two months.

The manner in which the perfect insect lays its eggs is difficult to determine, owing to its obscure colour and extremely rapid movements. The great agitation of the sheep also interferes with accurate observation, but its general motions and method of defence leave little doubt that the eggs are deposited on the inner margin of the nostril. "The moment," Mr Clark observes, "the fly touches this part of the sheep, they shake their heads, and strike the ground violently with their fore feet; at the same time, holding their noses close to the earth, they run away, looking about them on every side, to see if the fly pursues; they also smell to the grass as they go, lest one should be lying in wait for them. If they observe one, they gallop back, or take some other direction. As they cannot, like the horses, take refuge in the water, they have recourse to a rut, or dry dusty road, or gravel pits, where they crowd together during the heat of the day, with their noses held close to the ground, which renders it difficult for the fly to get at the nostril." Mr C. imagines that the last-named part, from the constant attacks, and the consequent rubbing upon the ground, becomes inflamed and painful, which occasions their touch to be so greatly dreaded by the sheep.

The *Œstrus Bovis*, in the perfect state, is a very beautiful insect, and one of the largest of the European species. The wings are without spots; the abdomen has a central band of black, and is clothed at the extremity by reddish-yellow hairs. Although its effects on cattle have been often remarked, yet the fly itself, as Mr Clark has observed, is rarely seen or taken, "as the attempt would be attended with considerable danger." It inflicts greater pain in depositing its eggs than any other species. "When one of the cattle is attacked with this fly, it is easily known by the extreme terror and agitation of the whole herd: the unfortunate object of the attack runs bellowing from among them to some distant part of the heath, or the nearest water, while the tail, from the severity of the pain, is held with a tremulous motion straight from the body, in the direction of the spine, and the head and neck are also stretched out to the utmost. The rest, from fear, generally follow to the water, or disperse to different parts of the field. And such is the dread and apprehension in the cattle, of this fly, that I have seen one of them mee the herd when almost driven home, and turn them back, regardless of the stones, sticks, and noise of their drivers; nor could they be stopped till they reached their accustomed retreat in the water. When oxen are yoked to the plough, the attack of this fly is attended with rea danger, as they become perfectly uncontrollable, and wil often run with the plough directly forwards, through the hedges, or whatever obstructs their way." The attack of this small but dreaded foe has indeed been often described, and by none with more of taste and accuracy than b the "Mantuan Bard."

> Est lucos Silari circa, ilicibusque virentem
> Plurimus Alburnum volitans, cui nomen Asilo
> Romanum est, Œstron Graii vertere vocantes:
> Asper, acerba sonans: quo tota exterritu sylvis
> Diffugiunt armenta; fusit mugitibus æther
> Concussus, sylvæque et sicci ripa Tanagri.[1]

The female deposits her eggs with great rapidity, and does not remain above a few seconds on the back of the animal. The larvæ live beneath the skin, between it and the cellular membrane, in a proper sack or abscess, rather larger than the insect. When young they are smooth, white, and transparent, become darker as they increase, and when full grown are of a deep-brown colour. After a time they work their way out, fall to the ground, and assume the state of chrysalis, in which they continue from about the latter end of June till towards the middle of August, when the perfect insect makes its appearance.

GENUS GASTRUS, Meig.; *Œstrus*, Linn.; *Gasterophilus*, Leach. (Plate CCXXXVIII. fig. 25, 28, and 28 *a*.) Antennæ with the lower joints small, the third compressed and furnished with a naked dorsal seta: mouth closed: halteres naked: wings without a transverse nervure at the apex. Meig. *Zw.* iv. tab. xxxviii. fig. 18–23.

G. *Equi*. Head with fine hairs, yellowish grey, the forehead rather darker, with two reddish-brown vittæ: antennæ ferruginous: thorax anteriorly with ferruginous pubescence, that on the hinder part of a darker colour, the sides with rather long glistening hairs passing into whitish yellow: scutellum with black pubescence behind: abdomen ferruginous, the pubescence fine, with a silky gloss; the back with a triangular blackish spot on each of the segments, and sprinkled with several small spots, at least in the male: legs and halteres ferruginous: wing-scales white: wings whitish; having a waved brownish-grey band across the middle, and two spots of the same colour at the apex: the ovipositor of the females is thick, cylindrical, and of a shining black colour. Five lines. Meig. *Zw.* iv. pl. xxxviii. 21, 22; *Œs. Bovis*, Linn.; *Œ. Equi*, *Linn. Trans.* iii. 298, pl. xxiii. f. 7–9.

Not common in Britain. This species, likewise known by the name of breeze or gad-fly, usually frequents elevated heathy districts, and we have observed it flying about the summits of the Westmoreland hills,[2] and those of Roxburghshire. Mr Bracy Clark has also furnished us with some valuable information on the manners and metamorphosis of this insect, the larvæ of which are commonly called *bots*. "The mode pursued by the parent fly to obtain for its young a situation in the stomach of the horse is truly singular, and is effected in the following manner:—When the female has been impregnated, and the eggs are sufficiently matured, she seeks among the horses a subject for her purpose, and approaching it on the wing, she holds her body nearly upright in the air, and her tail, which is lengthened for the purpose, curved inwards and upwards: in this way she approaches the part where she designs to deposit the egg, and suspending herself for a few seconds before it, suddenly darts upon it, and leaves the egg adhering to the hair: she hardly appears to settle, but merely touches the hair with the egg held out on the projected point of the abdomen. The egg is made to adhere by means of a glutinous liquor secreted with it. She then leaves the horse at a small distance, and prepares a second egg, and, poising herself before the part, deposits it in the same way. The liquor dries, and the eggs become firmly glued to the hair: this is repeated by various flies till 400 or 500 eggs are sometimes placed on one horse. The horses, when they become used to this fly, and find it does them no injury, as the *Tabani* and *Conopes*, by sucking their blood, hardly regard it, and do not appear at all aware of its insidious object."[1] The inside of the knee is the part usually chosen, although other places are sometimes selected. It is worthy of note, however, that these ova are always laid where they are most liable to be licked off by the horse's tongue. It is not, however, precisely the eggs themselves which are conveyed into the interior of the animal. Mr Clark found that after they have remained four or five days on the hairs, they became *ripe*,—after which the slightest application of warmth and moisture is sufficient to bring forth the latent larva in an instant. "At this time, if the tongue of the horse touches the egg, its *operculum* is thrown open, and a small active worm is produced, which readily adheres to the moist surface of the tongue, and is from thence conveyed with the food to the stomach." Mr Clark has often clipped off some hairs with eggs on them, and holding them in his hand, moistened with saliva, has seen them hatched in a few seconds. If the larvæ pass the dreadful ordeal of mastication, and are transmitted uninjured to the horse's stomach, they attach themselves to every part of it, but are generally most numerous about the *pylorus*. Sometimes, but much less frequently, they occur in the intestines. Their numbers are very various,—from half a dozen to above a hundred. They generally hang in clusters, being fixed by the small end to the inner membrane of the stomach, to which they adhere by means of two small hooks or *tentacula*. When removed from the stomach they will attach themselves to any loose membrane with which they may come in contact, and even to the skin of the hand. On attaining to their full size, they pass by the intestinal canal, drop to the ground, and enter the chrysalis state. Upon the whole, Mr Clark does not regard these insects as hurtful to horses, but rather views them favourably, as natural *stimuli*. Valisnieri, however, considered them as the cause of the epidemic malady which in 1713 carried off so many horses in the territories of Mantua and the Veronese.[2]

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[1] *Georg.* lib. iii.

[2] On one occasion particularly, on crossing some hill pasture above Elleray, the seat of Professor Wilson, we were suddenly attacked by three of these insects. They flew round about us in a state of angry excitement, coming sometimes within a few inches of the face, and keeping so close to each other, that, having the forceps in hand, we captured the whole three at once, to their great surprise, and probably disappointment.

Four other species are found in Britain, besides the one to which the preceding observations more particularly apply,—viz. *Œ. hæmorrhoidalis, nasalis, Clarkii*, and *salutiferus*.[3]

FAMILY XXIII.—MUSCIDES.[4]

Antennæ inclined, three-jointed, obtuse beneath: the third joint with a seta on the back: proboscis concealed, geniculated at the base: thorax with a transverse suture: abdomen having from four to six segments. Meig. *Zw.* iv. xi.

GENUS XYSTA, Meig. Antennæ incumbent, shorter than the hypostoma, second and third joints nearly equal, compressed; the terminal one with a naked dorsal seta at the base: mouth with a mystax: abdomen convex, consisting of five or six segments: wings divaricating.

X. *cilipes*. Hypostoma and forehead greyish white, the last with a black line: palpi ferruginous, the apex brown: thorax dark grey, with three blackish lines: abdomen shining black, consisting of six segments; the two terminal segments grey, the apex having a shining black bent appendage: legs black, strong: the hinder tibiæ arched, dilated, and fringed with long black bristles: wing-scales white; halteres slender, black: wings hyaline, yellowish at the base. Three and a half lines. Meig. *Zw.* iv. 182, pl. xxxix. f. 5.

Two species only belong to this genus, both of which appear to be scarce on the continent, and neither of them has been observed in Britain.

GENUS PHASIA, Lat. Antennæ incumbent, shorter than the hypostoma, third joint rather longer than the second, obtuse; the base with a naked dorsal seta: mouth villose: abdomen depressed, pubescent, consisting of five segments: wings divaricating. Meig. *Zw.* iv. pl. xxxix. f. 6–16.

P. *subcoleoptrata*. Hypostoma whitish, with a pearly play of colour; forehead white, with a changeable dark grey line; antennæ blackish brown; thorax light grey, with four black lines, the two central ones abbreviated behind: scutellum cinereous: abdomen oval, flat, black brown in the male, with cinereous, and sometimes reddish-brown reflections, the apex golden yellow: that of the female black brown, with a dark dorsal line: wing-scales of the male brownish, of the female white: legs blackish: wings of the male broad, yellowish at the base, the anterior margin having a brown vitta extending rather beyond the middle, and there is another of the same colour along the centre, which is dilated at the apex so as to appear somewhat curved forwards; wings of the female comparatively narrow, hyaline, somewhat yellowish at the base. Male four, female three lines. Meig. *Zw.* iv. 190, pl. xxxix. f. 13.

Occurs in the northern parts of the continent of Europe and in Britain, but appears to be rare. *P. hemiptera, semicinerea*, and *pusilla*, are the only other kinds hitherto found in Britain, although the genus contains upwards of thirty species.

GENUS GYMNOSOMA, Meig.; from γυμνος, *naked*, and σωμα, *the body*. Antennæ with the second and third joints nearly equal; the terminal one compressed, linear, obtuse; with a naked dorsal seta at the base: mouth naked: abdomen nearly naked, globose, consisting of four segments: wings spreading. Meig. *Zw.* iv. pl. xxxix. f. 17–22.

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[1] See *Linn. Trans.* vol. iii. p. 298; and the Essay mentioned in preceding note.

[2] *Ragionamento intorno all' Œstre de Buoi.* Opere, t. i.

[3] Stephens' *Systematic Catalogue*, part ii. p. 296.

[4] The tribe Muscides of Latreille (excepting, we believe, the genera *Diopsis, Scenopina*, and *Achias*) has been recently created into a separate order, named MYODARIÆ, by M. Robineau Desvoidy. See an abstract of his views in the *Diction. Class. d'Hist. Nat.* t. xi. p. 365.

G. *rotundata.* Male. Hypostoma straw-colour, silky: forehead golden yellow, with a brownish vitta changing into red: antennæ black; the third joint ferruginous on the inner side at the base; thorax dull-ferruginous, with four brownish longitudinal lines, and a shining black transverse band behind: scutellum black: abdomen ferruginous, pellucid, with black spots on the back: legs black: wings brownish, ferruginous at the base: wing-scales dirty white.

Female. Hypostoma and forehead pearl-white; the frontal vitta brown: thorax cinereous on the sides and beneath. Four lines. *Musca rotundata*, Linn. Fab.; *Ocyptera rotundata*, Lat. On flowers and shrubs: found near London, and on the continent, not unfrequently.

Genus Ocyptera, Meig. (Plate CCXXXVIII. figs. 26 and 26 *a*.) Antennæ somewhat deflexed, third joint longer than the second, linear, compressed, obtuse, having a naked dorsal seta at the base: mouth furnished with a mystax: abdomen elongate, cylindric, subsetose, four-ringed: wings spreading. Meig. *Zw.* iv. pl. xxxix. f. 23–29.

O. *brassicaria.* Hypostoma and forehead silky white, the former with two narrow black lines, the latter with a broad black vitta: antennæ blackish: thorax anteriorly slate grey, with four black lines, the two in the centre narrow: abdomen with the first and second segments sanguineous, the former with a large triangular mark of black on the back, the two terminal segments black, the penultimate one silvery on the anterior margin: legs black: wing-scales pale white: wings brownish grey, the base ferruginous. Five to six lines. Meig. iv. 211, pl. xxxix. f. 29. Apparently a scarce species. It occurs near Edinburgh.

M. Leon Dufour, in a memoir on the insects of this genus, has shown that the larvæ of two species, *O. cassidæ* and *bicolor*, are parasitical,—the first in the visceral cavity of *Cassida bicolor*, the second in that of *Pentatoma grisea.* Each feeds upon the epiploon or fatty matter of his host.[1]

Genus Lophosia, Meig. Antennæ deflexed, the two basal joints minute, the third very large, compressed, triangular, with a naked dorsal seta at the base: mouth with a mystax: abdomen cylindric, composed of four segments: wings spreading. Meig. *Zw.* iv. pl. xl. f. 1–4.

L. *fasciata.* Hypostoma silky white; antennæ with the two first joints black, the third brown: thorax bristly, shining black above, dark grey on the sides, with a changeable cinereous spot on each shoulder: abdomen sub-cylindric, arched, slightly narrowed at the base, bristly, of a shining black colour, the anterior margin of the second and third segments changeable white: thighs black, somewhat pubescent, bluish white beneath, with a naked white spot on the inner side at the apex; anterior tibiæ blackish brown, posterior rufous: tarsi black: wings hyaline, with a broad obsolete cross band of a brownish colour before the apex. Five lines.

This genus is readily distinguishable from all the allied genera by the large and distinctly trigonate terminal joint of the antennæ. It contains but one species, which occurs on the continent.

Genus Phania, Meig.; named from φανος, because most of the species are pellucid. Antennæ deflexed, third joint elongate, linear, compressed, obtuse; the base with a naked dorsal seta: mouth with a mystax: abdomen consisting of four segments, the apex elongate, and bent inwards: wings spreading. Meig. *Zw.* iv. pl. xl. f. 5–10.

P. *curvicauda.* Head silver white, with a black play of colour: palpi and antennæ black brown; the third joint with a finely pubescent seta, thickened at the base; forehead with a deep black line, broadest in the female: body shining black, bristly, except on the shoulders, where there are white spots: wing-scales white: halteres black brown; wings brownish grey, the base yellowish: legs black. Meig. iv. 221, pl. xl. f. 10. Rare: it occurs in Britain along with two other species, *P. vittata* and *thoracica.*

Genus Trixa, Meig. Antennæ incumbent, short; second and third joints equal, terminal ovate, having a naked dorsal seta at its base: hypostoma villose, without a mystax: wings spreading, with a transverse nervure at the apex. Meig. *Zw.* iv. pl. xl. f. 11–16.

T. *dorsalis.* Hypostoma cinereous; palpi and antennæ black brown: thorax ash grey, with four black lines: scutellum black: abdomen rufous, having a broad dorsal line of black, which at the base of the segments changes with a play of colour into whitish grey; the third and fourth segments have a similar play of colour on the sides; wing-scales white: wings greyish; the small cross nerve of the middle rather thick, black, edged with brown: legs black; tibiæ and tarsi faintly rufescent. Five lines. Inhabits Britain, but is scarce. Only one other species of the six described by Meigen is known to be British,—*T. variegata*, which has occurred in the neighbourhood of London, in Dumfriesshire, and near Edinburgh.

Genus Miltogramma, Meig. Antennæ incumbent, third joint elongate, linear, compressed; the base with a naked dorsal seta: mouth setose: wings spreading, the apex with a transverse nervure. Meig. *Zw.* pl. xl. f. 17–26.

M. *fasciata.* Hypostoma white, with flesh-coloured play of colour: palpi and antennæ clear reddish yellow; the frontal vitta rather broad: thorax and scutellum cinereous, with three black lines: abdomen conical, the first segment black, the following white anteriorly, and banded with black behind; on the sides the white passes with a play of colour into brownish red: legs black: wing-scales white. Four lines. Meig. iv. 227, pl. xl. f. 26.

The males have been found in Germany, the females are unknown.

Genus Tachina, Illig. Antennæ deflexed or incumbent, the third joint truncated beneath; the base with a naked dorsal seta: mouth with a mystax: wings spreading, having a transverse nervure at the apex. Meig. *Zw.* iv. 234, pl. xl.

T. *grossa.* Head ferruginous, with a brown frontal line changing into ferruginous; palpi ferruginous, with black bristles; antennæ blackish brown at the base; second joint ferruginous, third sub-quadrate, brown with a yellowish play of colour: seta black: body shining black: wing-scales dark brown: wings greyish, the base ferruginous: legs black. Eight lines. Meig. iv. 239. *Musca grossa*, Linn.; *Echinomyia grossa*, Lat. Found occasionally in most parts of Britain. We took it in Sutherland. It is one of the largest of the European Diptera. The larva lives in the dung of cattle, and is described by Réaumur. We may observe that the genus Tachina, notwithstanding the labours of recent writers, is still a great magazine of ill-assorted species. Considerably above three hundred occur in Europe.

Genus Gonia, Meig.; from γονια, *an angle*, referring to the form of the antennal seta. Antennæ deflexed, incumbent, the third joint elongate, prismatic, the base with a naked seta, which is three-jointed and geniculate:

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[1] *Annales des Sciences Nat.* t. x. p. 248. See also *Règne Animal*, t. v. p. 513.

Diptera Proboscideæ.

eyes remote: wings spreading, the apex with a transverse nerve.

G. *capitata.* Head reddish-yellow, with a whitish play of colour; palpi ferruginous; antennæ dark brown; the second joint ferruginous: thorax blackish, passing into brown on the back, with an ash-grey play of colour, and marked with four black lines; scutellum brownish yellow: abdomen pellucid, ferruginous, shining, with an indistinct dorsal line of black; the first and second incisures have a very narrow, and the third a wider edge of changeable whitish yellow: belly ferruginous; legs black: wing-scales white: wings somewhat grey, with the base yellowish. Six to seven lines. *Musca capitata*, Degeer, *Ins.* vi. 12, 2.

This genus is of limited extent, not including more than a dozen species. Two of these, besides the above, occur in Britain, but are by no means common. *G. capitata* seems to be most plentiful in Sweden.

Genus Zeuxia, Meig. Antennæ incumbent, the second and third joints equal, the third or terminal one compressed and obtuse, having a plumose dorsal seta at the base: mouth with a mystax, and clavate projecting palpi: wings spreading, the apex with a transverse nerve.

Z. cinerea. Hypostoma white: forehead wide, bristly, white with a small black line: palpi extended horizontally, large and clavate, ferruginous; antennæ brown: thorax bristly, having a suture across the back, the colour pale grey, with four black lines anteriorly, and three behind, the central ones much narrower than those at the sides: abdomen bristly, conical, four-ringed, and of an ash-grey colour changing into brown: legs black: wing-scales large, the halteres covered: wings nearly hyaline. Three lines. Has been found in Germany.

Genus Idia, Meig. Antennæ incumbent, the third or terminal joint oblong, having a dorsal seta at the base, plumose on one of the sides: palpi projecting, clavate: wings with a transverse nerve at the apex.

I. *fasciata.* Hypostoma shining black, spotted with white, and not furnished with a mystax: antennæ shorter than the hypostoma, and of a brown colour: thorax ash-grey, the colour playing into black, with three broad lines of black down the middle: scutellum grey, with a blackish play of colour: abdomen oval, black, with three rufous interrupted bands: belly yellowish red: legs black: wing-scales white, entirely covering the halteres: wings greyish. Three lines. Has been found at Marseilles, and on the hills near Frejus, but is very rare.

Genus Mesembrina, Meig. The generic term is a Greek word signifying meridian. Antennæ incumbent, the third or terminal joint oblong, prismatic, having a plumose dorsal seta at the base: body hirsute: wings spreading, and furnished with a transverse nerve at the apex.

M. *meridiana.* Hypostoma black, with a large angular spot of a bright gold colour on each side: forehead shining black, with a dull black streak: palpi black: antennæ dark brown, the seta ferruginous at the base: body and legs shining black; the two last joints of the anterior tarsi brown in the males, all the onychii yellow: halteres brown: wing-scales, and likewise the base of the wing, ferruginous. Six lines. *Musca meridiana*, Linn. Fab. Common throughout Britain during the summer and autumnal months, on flowers and in woods—often seen resting on the stems of trees.

The larva of this species lives in cow-dung. It is yellow, conical, and composed of many segments. At the mouth or narrowest end it has only one hook, and four short fleshy horns or warts. The hinder end or anus is, as it were, four-cornered and truncated, and has two circular brown spots, which are slightly raised, and are each perforated by a single air-hole. The two anterior air-holes are placed on the sides of the first segment. The larva changes itself in its own skin into a dark-brown nymph, which is nine-cornered behind, or nearly circular, and the posterior air-holes are observable. In summer the fly appears in a few weeks, but the nymphs formed late in the season continue throughout the winter, and produce the perfect insect in the spring.

The species of this genus are not regarded as generically distinct by Latreille, but form part of his genus *Musca*, or *Mouches proprement dites.*

Genus Sarcophaga, Meig. Named from σαρξ, *flesh*, and φαγω, *I eat.* Antennæ incumbent, the third or terminal joint oblong, prismatic, the base with a plumose seta, naked at the apex: eyes not united: wings spreading, and furnished with a transverse nerve at the apex. Meig. *Zw.* v. 14, pl. xliii. fig. 1–10.

S. *mortuorum.* Head silky golden yellow, with a reddish play of colour; palpi ferruginous; antennæ fulvous, changing into whitish grey; line down the forehead reddish brown, changing into golden yellow: thorax blackish, with a grey play of colour, and black lines: abdomen shining steel blue; belly and legs black: wing-scales white: wings greyish. Five to six lines. *Musca mortuorum*, Linn. Fab. Frequent in the south of Scotland, in England, and apparently throughout the north of Europe, except Germany, where it is said to be rare.

In this genus the eggs are not unfrequently hatched within the body of the mother, which has induced their being regarded as viviparous,—strictly, *ovoviviparous.* Of this kind is the *S. carnaria* (*Musca carnaria*, Linn.), a species somewhat larger than the common flesh-fly (*M. vomitoria*). The female deposits her living larvæ on meat, carcasses, and even on wounded or diseased subjects of the human race.

Genus Dexia, Meig. Antennæ incumbent, the third or terminal joint elongate and compressed, with a densely plumose seta at the base: abdomen conical (in the male) or oblong-elliptical (in the female): wings spreading.

D. *compressa.* Hypostoma of a shining silvery hue, with a black play of colour; forehead shining black, with a deep-black vitta; palpi rufous; antennæ nearly the length of the hypostoma, slender, the seta with a short plume: thorax bluish grey, with two wide shining black lines, which are continued over the grey scutellum to the sides: abdomen somewhat compressed on the sides, shining rufous, with a blackish line on the back spotted with grey; the incisures bright silver white, with a play of colour; legs black, with rufous thighs: wing-scale large and white: wings with a marginal spine, brown, clouded, and yellow at the base. Four to five lines. *Ocyptera rufa*, Fab.; *Musca rufiventris*, Fallen. Rather scarce: has been found in Germany, Spain, England, and some other parts of Europe. Twenty-four species are referred to this genus, fourteen of which seem to be indigenous to Britain.

Genus Musca, Linn. Antennæ incumbent, the third joint elongate, obtuse, compressed in a prismatic form, the base with a plumose dorsal seta: abdomen ovate, setose: wings spreading, the apex with a transverse nerve.

M. *maculata.* Male. Hypostoma white, with a brown play of colour; forehead white, with a blackish vitta, which becomes narrow above; palpi black: thorax whitish, with four broad black lines, the two central ones united behind the cross suture, and drawn over the scutellum in the form of a lozenge; the scutellum having a black spot on the side: abdomen globose, grey, with a light testaceous-red play of colour, and several deep black spots of different form and size: legs black; wing-scales dirty white: wings somewhat brownish.

Female. Forehead wide, whitish, with a deep-black double vitta: thorax light grey, the lines narrower than in the male: abdomen light grey, rarely inclining to testaceous; the spots and other characters as in the other sex. Four lines. *Musca maculata*, Gmelin. Degeer. *Ins.* vi. 41, 13. In summer and harvest in hedges and on flowers; not rare. It is frequent in Roxburghshire during the autumn on the flowers of *Senecio Jacobæa.* Many of the insects of this genus are very common. *M. Cæsar*, distinguished by its brilliant golden-green colour, and *M. vomitoria*, commonly called the *flesh-fly*, are abundant on carcasses throughout Europe. The common house-fly, *M. domestica*, is remarkable for its extensive distribution, being found in Pennsylvania, New Orleans, and other parts of the new world.

We may observe in regard to the last-named species, that it is subject to a singular disease, of which the cause is not yet known. A white crust forms upon the abdomen, which becomes greatly distended, and the segments become distant from each other, so as to produce a ringed appearance. In this condition it is frequently found dead, adhering to walls, and sometimes to the stalks or leaves of plants. Its body is at this time filled with a fatty matter, which has been observed to have exploded on all sides through the pores.

Genus Anthomyia, Meig.; from ανθος, *a flower*, and μυια, *a fly*. Antennæ deflexed, the third or terminal joint oblong, compressed, obtuse, the base with a plumose, pilose, or naked seta; the frontal vitta obscure, narrowed above in the male: mouth with a mystax: abdomen consisting of four segments, setose: wings spreading or incumbent, without a transverse nerve at the apex.

A. *Angelicæ.* Hypostoma and forehead white, the former with a blackish play of colour: thorax bright grey in the male, inclining to ferruginous in the female: scutellum and abdomen ferruginous, the last without a brown play of colour; the black dorsal line does not extend to the hinder extremity, and in the female it is usually interrupted on the third segment: legs rufous, with brown tarsi. Four lines. *Musca Angelicæ*, Scop. *Ent. Cariol.; Musca deceptoria*, Gmel. Schrank. Abundant in woods in the south of Scotland, and apparently equally plentiful in England.

The genus Anthomyia contains upwards of two hundred European species, more than the half of which have been found in Britain. In addition to the one described above, we may name two other well-known species of the genus *A. meteorica* and *pluvialis*, Linn.

Genus Drymeia, Meig. Antennæ deflexed, the third joint oblong, compressed, obtuse at the apex, with a pubescent dorsal seta at the base; forehead with an obscure vitta; the eyes of the male united: mouth with a mystax: proboscis slightly projecting, the capitulum oblong, and furnished with a hook: abdomen four-ringed, setose: wings incumbent, parallel, without a transverse nerve at the apex.

D. *obscura.* Hypostoma white, with a blackish play of colour; antennæ half the length of the hypostoma, black; thorax shining black, bristly, with a cross suture; that of the female inclining to grey, and having two indistinct longitudinal lines of a dark colour: abdomen rather long, bristly, ash-grey, with spots and a line along the back of changeable black; flat in the male, arched in the female, and acute behind: wing-scales small and white: halteres black: legs of the same colour: wings somewhat brownish. Three to four lines. Found in August and September, not unfrequently, in many parts of the continent. Another insect, presenting generic characters somewhat similar to the above, has been found in England, and is named *D. hispida:* some doubt, however, attaches to the propriety of referring it to this genus.

Genus Eriphia, Meig. Antennæ incumbent, the third joint oblong and compressed, the apex obtuse, and having a naked dorsal seta at the base: mouth very hirsute: eyes of the male united: abdomen four-ringed, the apex very hirsute in the male: wings without a transverse nerve at the apex.

E. *cinerea.* Male. Hypostoma grey, shining white on the sides; forehead black, changing into grey; antennæ black: thorax bristly, rather glossy black, with a faint grey play of colour, and marked with three black lines: abdomen with the first segment black, the following three ash-grey, having a dark-brown play of colour, and a black line on the back; the second and third with a black band behind: wing-scales small, yellowish: halteres black: wings somewhat brownish: legs black. Four lines. Found by M. Baumhauer at Genisberg.

Genus Dialyta, Meig. Antennæ incumbent, the length of the hypostoma, the third joint long, compressed, obtuse at the apex, with a naked dorsal seta at the base: mouth with a mystax: eyes equally remote: abdomen four-ringed, pilose: transverse nerve at the apex of the wing wanting.

D. *erinacea.* Hypostoma silky white, with a black play of colour; forehead shining black, with a deep black vitta changing into whitish grey; palpi black, bristly; the antennæ likewise black: body shining black; thorax somewhat hoary, having two scarcely perceptible longitudinal lines, and a distinct prominence on the shoulders: abdomen of the males rather long, elliptical, flat, arched, somewhat greyish, the incisures and a line on the back black, but very faintly marked; that of the female oval, pointed, much arched, and shining black: wing-scales white; halteres black: wings broad, ferruginous at the base: legs black. Three to four lines. A rare species, the native country of which is not yet known.

Genus Coenosia, Meig. Antennæ incumbent, the third or terminal joint long, linear, compressed, with a seta at the base, which is either plumose, or pubescent, or naked: mouth with a mystax: eyes distant, those of the male somewhat approximating: abdomen four-ringed, setose, clavate at the apex in the male: wings incumbent, without a transverse nerve at the apex. The insects of this genus, which is of considerable extent, are found in hedges and on flowers, the smaller kinds are most abundant among grass. With the exception of the species described below, we are not acquainted with their habits and metamorphoses.

C. *fungorum.* Hypostoma white, changing into brown; forehead black, the hinder part of the head ash-grey; palpi and antennæ black, the seta of the last distinctly plumose: thorax grey, with four black lines, which, however, are often indistinct: abdomen rather long, rufous; sometimes with a brownish dorsal line: legs rufous, with black tarsi: wing-scales and halteres white: wings somewhat clouded. The scutellum is sometimes ferruginous, as well as the shoulders. Three and a half lines. The larva of this insect lives in mushrooms, is four and a half lines long, of a whitish-grey colour, with two hooks on the head, the hinder part thick and obtuse. It undergoes its metamorphosis in the earth.

Genus Lispe, Meig. Antennæ incumbent, the terminal joint elongate, compressed, obtuse at the apex, and having a plumose seta at the base: eyes distant: palpi somewhat projecting, slender, spoon-shaped at the apex: abdomen ovate, four-ringed: wings incumbent.

L. *tentaculata.* Male. Hypostoma silky whitish yellow; the frontal vitta wide, and blackish grey; palpi of a shining silvery hue, with a yellow play of colour: thorax greyish black, with dark indistinct longitudinal lines: abdomen flat, ovate; the first segment grey, the following black; the second and third segments with a rounded white spot on the back, and another on each side of a triangular form placed at the anterior edge; the fourth having only the two triangular spots: legs black; the anterior tarsi have the first joint somewhat shorter than the second, and black, the rest yellowish; wing-scales and halteres white; wings rather grey.

Female. Hypostoma bright yellow; the spots on the abdomen grey; the legs wholly black, the tarsi all alike. Three lines. *Musca tentaculata*, Degeer. Found in Germany, and various other parts of the north of Europe. In Britain it has occurred near London, and seems to be the only species of the genus belonging to this country.

Genus Cordylura, Fallen. Antennæ deflexed, the terminal joint oblong, compressed, truncated at the apex, the base with a seta, which is either plumose or villose: head sphæroidal, the hypostoma scarcely descending, and furnished with an imperfect mystax; eyes distant, globose: abdomen five or six ringed, that of the male linear and clavate at the apex; wings incumbent, parallel, the length of the abdomen.

C. *pubera.* Hypostoma white; palpi black: antennæ shorter than the hypostoma, black, with a plumose seta: forehead of the male not so wide as that of the female, black, with a greyish-white play of colour, sometimes changing anteriorly into reddish yellow: body bristly, shining black; thorax with a line of changeable white in the middle of the front: the sides of the thorax changing into bluish white: wing-scales and halteres white: wings rather dull, the base and anterior margin ferruginous: thighs black, the tibiæ and tarsi testaceous, the latter in the male spotted on the under side with black. Four lines. *Musca pubera*, Linn. Fab. Meig. *Zw.* pl. xlv. fig. 22, *female.* Of occasional occurrence in the southern parts of England.

Genus Scatophaga, Meig.; from σκατος, *dung*, and φαγω, *to eat.* Antennæ deflexed, the terminal joint elongate, prismatic, obtuse, the base with a seta, which is either plumose or naked; head spheroidal, the hypostoma descending, and furnished with a mystax: eyes distant, rounded: abdomen five-ringed, linear in the male: wings incumbent, parallel, much longer than the abdomen.

S. *scybalaria.* Hypostoma, antennæ, and frontal vitta rufous, the latter very wide; palpi whitish; thorax brownish yellow, with obsolete lines: abdomen brownish yellow, that of the male thick, and clothed with rufescent hairs; legs ferruginous, pubescent; wing-scales small and yellow: halteres yellow: wings large, ferruginous, with brown nervures, the transverse nerve in the middle black, and usually a little bent. Five lines. *Musca scybalaria*, Linn. Fab. This species is of frequent occurrence in Britain. *S. stercoraria* and *S. merdaria* are among our most common insects, and most of the species described by Meigen, amounting to fifteen in number, are inhabitants of this country.

Genus Dryomyza, Fallen. Antennæ incumbent, approximating, the third or terminal joint oblong, obtuse, prismatic, with a villose seta at the base: head spherical; the hypostoma descending, coarctate, naked, blunt below: eyes remote, rounded: abdomen oblong, five-ringed: wings incumbent, very much longer than the abdomen.

D. *flaveola.* Light ferruginous, shining: hypostoma bright yellow, especially on the sides; antennæ black brown, with a dark-yellowish base, and a long black pubescent seta: thorax with two brownish approximating lines on the back; on the abdomen are likewise four brownish lines, but these, properly speaking, are the interior vessels shining through: legs ferruginous, becoming brownish at the extremity: halteres clear yellow; the wings hyaline. Five lines. *Musca flaveola*, Fab. Not rare in Britain, nor in most other parts of Europe.

Genus Sapromyza, Fallen. Antennæ deflexed, the third or terminal joint oblong, compressed, obtuse at the apex, the base with a seta, which is either shortly plumose or villose: head sub-hemispheric, the hypostoma somewhat descending, naked, flat: eyes distant, rounded; abdomen oblong, five-ringed: wings incumbent, parallel.

S. *rorida.* Entirely pale yellow, the seta of the antennæ short and plumose: hypostoma and incisures of the body whitish: wings of a yellowish tint. Two lines. Found during summer, not unfrequently.

Genus Ortalis, Fallen. Antennæ deflexed, oblique, the third or terminal joint oblong, compressed, and having a naked seta at the base: hypostoma arched in the middle, naked; the forehead hirsute; eyes oblong; abdomen five-ringed: wings erect (vibrating).

O. *vibrans.* Hypostoma and forehead very bright orange yellow, with the margin of the eyes whitish: antennæ rufous, with a finely pubescent seta: body shining bluish black: halteres white: wings hyaline, the first longitudinal nerve thick, and of a black colour; the apex of the wing occupied by a triangular blackish-brown spot: legs black. Two and a half lines. *Musca vibrans*, Linn. Fab. Degeer. Don. x. 54, pl. cccxlvi. fig. 3. *Tyrophaga vibrans*, Curtis, *B. E.* fol. 126. This insect, which forms the genus *Seioptera* of Kirby, is of frequent occurrence throughout England and the southern district of Scotland. It is rare in Germany, but is plentiful in Sweden and most other northern countries.

Genus Sepsis, Fallen. Antennæ incumbent, the terminal joint oblong, obtuse, compressed, with a naked seta at the base: head globose; the hypostoma flat, and furnished with a mystax; eyes rounded, distant: abdomen four-ringed, petiolate, sub-cylindric, naked: wings erect (vibrating). These lively little insects, which are in constant motion, are found on bushes, in hedges, and among grass, almost everywhere, and are for the most part very common from the first bright warm days of spring to the end of harvest: they probably continue during winter. Their natural history is not known.

S. *cynipsea.* Head shining black; antennæ brown: body shining black, with metallic lustre: legs black; anterior coxæ yellow, the thighs black; tibiæ rufous, inclining to testaceous; and in the hinder legs the base of the thighs is rufescent. One and a half line. *Musca cynipsea*, Linn.; *Micropeza cynipsea*, Lat. Common in England and the south of Scotland. In the vicinity of Edinburgh *S. cylindrica* is common, and we have likewise observed *S. nigripes*, *S. violacea*, and *S. punctum.*

Genus Cephalia, Meig. Antennæ incumbent, the third joint elongate, compressed, gradually attenuated, with a pubescent dorsal seta at the base: hypostoma descending, naked; the proboscis standing out: eyes distant, rounded: abdomen four-ringed: wings . . . .

C. *rufipes.* Hypostoma testaceous; forehead black; palpi black; antennæ blackish brown, rufescent at the base: body black, naked: sides of the thorax, breast, and scutellum testaceous: halteres white, not covered; scarcely a trace of the wing-scales is perceptible; legs slender, testaceous: wings hyaline, the first longitudinal nerve thick and black, the apex with a brown spot. Has been found at Berlin and in Austria.

Genus Lauxania, Lat. Antennæ projecting obliquely, remote, the third or terminal joint elongate, compressed, obtuse, with a shortly plumose seta at the base: hypostoma somewhat descending, impressed in the middle: eyes remote, oblong: abdomen ovate, five-ringed: wings parallel, incumbent.

L. *cylindricornis.* Shining black; eyes during life green, with four purple bands; antennæ projecting straight forwards, longer than the head, dark brown, with a whitish pubescent seta; hypostoma shining black, with the lateral edge glistening white; forehead with a dull-black vitta: wing-scales and halteres black; legs black, the hinder tarsi yellow; wings yellow, black at the base. One and a half line. *Sargus cylindricornis*, Fab.; *Musca chrysoptera*, Schrank. Frequent in summer among grass and brushwood.

GENUS LONCHÆA, Fallen. Antennæ incumbent, approximating, the third or terminal joint oblong, compressed, obtuse at the apex, and having a naked seta at the base: hypostoma flat, somewhat descending, naked: eyes oblong, the forehead of the male narrow, of the female wide: abdomen ovate, villose, six-ringed: wings incumbent, parallel.

L. *nigrimana.* Male. Antennæ brown, shorter than the hypostoma, the third joint ovate, flat: forehead flat, dull black: body shining greenish black: wings pale yellow: legs black: the middle and hinder tarsi rufescent. Two lines. Found in the vicinity of London, along with eight other species of this genus.

GENUS TRYPETA, Meig. (Plate CCXXXVIII. fig. 29.) Antennæ incumbent, approximating, the third joint oblong, compressed, obtuse at the apex, and having a seta at the base which is either naked or pubescent: hypostoma somewhat descending, flat, naked: eyes somewhat rounded, distant; the forehead wide and setose: abdomen five-ringed, the apex obtuse in the male, but furnished with a projecting style in the female: wings erect (vibrating).

T. *Zoë.* Honey-yellow, shining, the metathorax bright black: the wings of the male have two dark-brown spots at the anterior border, the smaller one lying above the small cross nerve, and having a small branch projecting forwards from behind; the other, which is much larger, occupies the apex, extending scarcely beyond the fourth longitudinal nerve: in the female the wings have a large brown spot before the middle, and another at the apex, with a narrow cross band, sometimes interrupted, at other times indistinctly marked, in the space between. Male one and a half, female two lines. In the neighbourhood of Edinburgh, and near Jedburgh; not common.

Several different names have been bestowed on this genus. It is named *Traupanea* by Schrank, and *Tephritis* by Latreille: the latter seems to be most generally adopted. To this genus belongs the insect which, in the Isle of France, is so destructive to the lemon crop, by depositing its eggs in that fruit. Its multiplication is sometimes extreme.

GENUS TETANOPS, Fallen. Antennæ small, distant, projecting obliquely, the third joint ovate, compressed, the base with a naked dorsal seta: hypostoma reclined, descending, carinated, naked; forehead projecting, flat, naked: abdomen five-ringed, the style of the female incurved and jointed.

T. *myopina.* Hypostoma and forehead greyish white; antennæ reddish yellow: thorax light grey, the scutellum of a similar hue: abdomen in the male with the two first segments light grey, unspotted, the two following shining black, having the hinder margin and a line on the back grey, the fifth entirely black; in the female it is light grey, with a black spot on each side of the segments: legs reddish yellow; wings hyaline, with light-brown spots and black transverse nerves. Two to three lines. This seems to be a rare insect. It has been found in England.

GENUS PSILA, Meig. Antennæ deflexed, oblique, somewhat remote, the third or terminal joint oblong, compressed, obtuse at the apex, and having a villose dorsal seta at the base: hypostoma reclined, flat, naked, descending: eyes remote, rounded; forehead naked: abdomen six-ringed, the style of the female jointed and acute: wings incumbent, parallel, the first longitudinal nerve simple.

P. *Rosæ.* Shining black, slightly glossed with brassy: head rufous; forehead occasionally with a black longitudinal line; palpi yellow, the apex black: antennæ rufous, the apex blackish, the seta white and pubescent: legs bright yellow; halteres white; wings hyaline. Found in May and September in England and elsewhere. Seven of the thirteen species described by Meigen are natives of Britain.

GENUS LOXOCERA, Meig. Antennæ projecting obliquely, longer than the head, the third or terminal joint very long, linear, compressed, with a villose dorsal seta at the base: hypostoma reclined, flat, naked, descending: eyes distant, rounded: forehead somewhat projecting, naked: abdomen elongate, six-ringed, naked: wings incumbent, parallel; the first longitudinal nerve simple.

L. *ichneumonea.* Hypostoma rufous, the sides with a silvery play of colour; forehead testaceous, with a shining black triangular spot: antennæ half the length of the head, black, the first two joints red: thorax testaceous, the upper part of the neck shining black, the prominences on the shoulders, and two lines on the back, of the same colour; scutellum testaceous; abdomen black and shining; legs and halteres yellow; wings somewhat brownish. Three to four lines. Lat. *Musca ichneumonea*, Linn.; *Musca aristata*, Panz. Found in the southern parts of England, along with two other species, *L. elongata* and *L. sylvatica.*

GENUS CHYLIZA, Fallen. Antennæ deflexed, the third or terminal joint elongate, compressed, obtuse, with a villose dorsal seta at the base: hypostoma perpendicular, flat, without a mystax: eyes distant, oblong, the forehead pubescent: abdomen elongate, pubescent, six-ringed: wings incumbent, parallel, the first longitudinal nerve simple.

C. *atriseta.* Head thick, nearly quadrangular, shining black, with a whitish lustre at the margin of the eyes: antennæ sulphur-yellow, the first joint black, the seta longer than the antennæ, of a deep black, and having a short plume: body shining black; abdomen of the males slightly contracted at the base: legs bright yellow; the apex of the hinder thighs brownish: halteres light yellow: wings greyish, the margin from the middle to the apex brown. Three and a half lines. This insect occurs in Britain, as well as *C. leptogaster.*

GENUS LISSA, Meig. Antennæ projecting obliquely, small, the third or terminal joint ovate, compressed, with a villose dorsal seta at the base: hypostoma reclined, somewhat carinated, naked: eyes distant, oblong; the forehead tuberculated anteriorly: abdomen elongate, slender, six-ringed: anterior legs remote: wings incumbent, parallel, the first longitudinal nerve double.

L. *loxocerina.* Hypostoma black, with a silvery-white play of colour: forehead shining black: antennæ with the two first joints small and black, the third reddish yellow; hinder part of the head black, the margin of the eyes white: thorax black, clothed with fine white pubescence: abdomen elongate, cylindrical, black, with a white streak on each side at the incisures; that of the male club-shaped behind, in the female pointed: legs reddish yellow; the anterior pair remote from the hinder; anterior coxæ reddish yellow, thickly clothed with silver-white hairs; hinder coxæ black; the hinder legs longer than the others, and having the tibiæ brown in the middle: halteres yellow: wing-scales wanting. Four lines. Meig. *Zw.* vol. v. pl. lii. fig. 1–4. *Ocyptera dolium*, Fab. Inhabits Britain and some parts of the continent. The generic name is objectionable, as it was previously used by Dr Leach to designate a tribe of crustaceous animals.

Diptera Proboscidæ.

Genus Tetanura, Fallen. Antennæ projecting obliquely, the third or terminal joint elliptical, compressed, and obtuse, having a villose seta in the middle of the back: hypostoma perpendicular, carinated, nearly naked: eyes distant, rounded; the forehead flat and setose: abdomen elongate, cylindric, five-ringed: wings incumbent, parallel; the first longitudinal nerve simple.

T. *pallidiventris.* Hypostoma yellow; forehead shining dark brown, yellow in front, and having a spot of yellow on the crown; antennæ yellow: thorax black, bristly, the sides of the breast reddish yellow: scutellum black: abdomen pubescent, black, the first segment and hinder extremity of the terminal one pale yellow: legs rather long, ferruginous; the anterior pair rather remote from the hinder: halteres white, uncovered: wing-scales not visible: wings large, somewhat brownish. Two lines. Found by Professor Fallen at Esperod in Sweden, during the months of July and August. It is the only species of the genus, and has not hitherto been noticed in Britain.

Genus Tanypeza, Fallen. Antennæ somewhat incumbent, approximating, the third joint oblong, compressed, having a naked dorsal seta at the base; hypostoma somewhat reclined, flat, and naked: eyes oblong, remote; the forehead narrow and naked: abdomen elongate, six-ringed: wings incumbent, parallel; the fourth longitudinal nerve recurved.

T. *longimana.* Hypostoma blackish, with a white play of colour; forehead deep black, margined anteriorly with white, and having a white spot on the crown; palpi and antennæ deep black; the proboscis yellow: body shining black: thorax with an oblique slightly interrupted pubescent band, of a changeable white, on the sides: scutellum black and bristly: abdomen in the male with a small projecting piece behind, which bears a two-jointed seta near the apex, and a small protuberance anteriorly; in the female this appendage is short, pointed, and articulated: legs elongate, bright yellow; the first tarsal joint likewise yellow, and as long as the four following, which are brown: halteres white and naked: wing-scales white, so minute as to be scarcely perceptible: wings hyaline. Three lines. Examples of this species are preserved in the collections of Baumhauer and Fallen. We are unacquainted with its native country.

Genus Calobata, Meig. Antennæ incumbent, small, the third joint elliptical, compressed, the base with a dorsal seta, which is shortly plumose or naked: hypostoma flat, naked: eyes rounded; forehead nearly naked: abdomen elongate, cylindric, five-ringed: legs very long and slender; the tarsi short: wings incumbent, parallel.

C. *petronella.* Hypostoma whitish; palpi and antennæ yellow, the last black at the base, and furnished with a scarcely pubescent seta; forehead reddish yellow, margined with white, and having a black spot on the crown: thorax ash grey, with a yellowish callosity on each shoulder: scutellum grey: abdomen black, with whitish incisures; belly dark grey, wrinkled; style of the females rufous anteriorly, the second joint shining rust-brown, carinated: halteres white: wings hyaline: legs ferruginous, the hinder thighs brown at the apex. Three lines. *Musca petronella*, Linn. Found in England, likewise in the neighbourhood of Edinburgh, and other parts of the southern district of Scotland.

Genus Micropeza, Meig. Antennæ projecting, small, the third joint patelliform and compressed, having a long pubescent dorsal seta at the base: head elongate, elliptical; the hypostoma reclined and naked: eyes rounded, somewhat prominent, remote: abdomen elongate, cylindric, six-ringed: legs filiform, very long, the tarsi short; anterior legs remote: wings incumbent, parallel, the length of the abdomen.

M. *corrigiolata.* Hypostoma white; antennæ deep black, with a white seta; forehead black, deepening in the middle: body black: the sides of the thorax without a yellow vitta: abdomen with white incisures: halteres white: wings hyaline: legs yellow, with black tarsi; all the thighs having a black ring before the apex, and the apex itself black; tibiæ behind passing into black. Two lines. The female larger. Meig. *Zw.* v. 384, pl. liii. fig. 6. *Calobata filiformis*, Lat. Rather frequent. We once found it in very great abundance in the month of June, on flowers, by the sides of the Esk, near Dalkeith.

Genus Ulidia, Meig. Antennæ incumbent, small, distant, the third or terminal joint elliptical, compressed, with a naked dorsal seta at the base: hypostoma descending, impressed, naked, the proboscis somewhat prominent: eyes rounded, distant; the forehead broad, rugose, naked: abdomen ovate, depressed, five-ringed; wings incumbent, parallel.

U. *demandata.* Hypostoma fulvous, wrinkled, whitish above; antennæ dark yellow, the third joint with a brown spot anteriorly: forehead shining dark green, somewhat metallic, wrinkled: thorax more or less brassy; abdomen shining black: legs black; the tarsi rufous, with the apex black: wing-scales very small, and, together with the halteres, white: wings clear, with slender nerves. Two lines. *Musca demandata*, Fab. Meig. *Zw.* v. pl. liii. fig. 12. Has been taken near Paris, and in England.

Genus Timia, Meig. Antennæ distant, small, inserted in a foveola, the third joint oval, compressed, with a naked dorsal seta at the base: hypostoma descending, impressed in the middle, naked, the proboscis and palpi somewhat projecting: eyes oblong, distant; forehead villose: abdomen ovate, six-ringed: wings incumbent, parallel.

T. *apicalis.* Head black; forehead wide, and covered with fine pubescence: body shining black, somewhat setaceous, with a small prominence on each shoulder: abdomen finely pubescent: halteres and wing-scales small and white; wings clear, with the base yellowish, and a triangular brown spot at the apex. Three lines. Meig. *Zw.* v. pl. liii. fig. 16. Examples of this insect are preserved in Wiedemann's collection, and others have been obtained from Portugal.

Genus Platysoma, Meg. Antennæ deflexed, short, the terminal joint oblong, prismatic, obtuse, with a naked dorsal seta at the base: hypostoma somewhat descending, impressed, naked, the proboscis and palpi rather projecting; eyes rounded, remote, the forehead nearly naked; abdomen ovate, four-ringed: wings divaricating.

P. *seminationis.* Variegated with ash-grey and black: hypostoma and palpi black; antennæ dark brown: body grey, with black wartz-like points; abdomen pale beneath, the fourth segment as long as the others taken together: legs entirely black: halteres dark brown: wings marbled with fuscous. Two lines. *Musca seminationis*, Fab. Found in the southern parts of Britain, and on the continent.

Genus Piophila, Fallen. Antennæ incumbent, the third joint elliptical, compressed, with a naked dorsal seta at the base: hypostoma subreclined and provided with a mystax: eyes rounded, remote: the forehead broad, glabrous, convex, and setose: abdomen ovate, somewhat setose, glabrous, five-ringed: wings incumbent, parallel, longer than the abdomen.

P. *casei.* Shining black, glabrous: hypostoma and anterior part of the forehead rufous; antennæ rufous, the third joint, with the anterior edge and the apex, more or less black: hinder part of the head black: anterior legs black; base of the thighs and tibiæ rufous, the middle pair of legs entirely rufous; hinder legs rufous, the thighs before the apex with a black ring, more or less wide: anterior coxæ rufous: halteres white: wings hyaline. One and a half line. *Musca casei*, Linn. Var.; *Tyrophaga casei*, Curtis, *B. E.* vol. iii. fol. 126. Meig. *Zw.* v. pl. liv. fig. 4. The maggot lives in cheese, and leaps.

Genus Homalura, Meig. Antennæ deflexed, distant, the third joint patelliform, compressed, with a naked dorsal seta at the base: hypostoma descending, perpendicular, naked: eyes rounded and remote; the forehead broad, flat, and naked: abdomen ovate, depressed, naked, five-ringed: wings incumbent, parallel, the length of the abdomen.

H. *tarsata.* Body shining black, everywhere thickly covered with tubercular dots: thorax without a distinct cross suture: legs black, with yellow tarsi: stalk of the halteres black, the head globose and white. One and a half line. Meig. *Zw.* v. pl. liv. figs. 8 and 9. Inhabits Austria and England.

Genus Thyreophora, Lat. Antennæ very minute, inserted in a foveola, the terminal joint lenticular, and having a naked dorsal seta at the base: hypostoma descending, reclined, and having a mystax: eyes small and round; the forehead broad, rather prominent, convex, and villose: abdomen oblong, six-ringed: wings incumbent, parallel, longer than the abdomen.

T. *cynophila.* Head bright orange yellow; forehead pubescent, with two black spots: body dark steel blue, shining, everywhere beset with long black hairs: scutellum of the male nearly half the length of the abdomen, truncated at the apex, and bearing a strong seta at each side; that of the female small and triangular: legs dark steel blue, pubescent, the four anterior tarsal joints rufous at the base: wing-scales blackish: halteres white: wings hyaline, with two black dots on each. Four lines. Meig. *Zw.* v. pl. liv. figs. 10, 15. Has occurred in France.

Genus Actora, Meig. Antennæ small, distant, the third joint sub-globose, with a naked dorsal seta at the base: hypostoma perpendicular, descending, pubescent, without a mystax: eyes rounded, distant; the forehead broad, flat, villose: abdomen elongate, six-ringed: wings longer than the abdomen.

A. *æstuum.* Hypostoma white; forehead ferruginous and pubescent; antennæ dark brown: thorax light brown, finely pubescent, with small black dots; sides light grey, with a brownish spot before the base of the wings: scutellum semicircular, light brown: abdomen cinereous: legs dark grey, with rufescent tarsi; in the males the anterior tibiæ and tarsi are thickly covered beneath with shining whitish-yellow hair: wing-scales small and white: halteres white: wings hyaline. Four lines. Meig. *Zw.* v. pl. liv. figs. 19, 20. This insect has been taken in England by Dr Leach.

Genus Lipara, Meig. Antennæ distant, small, the terminal joint lenticular, with a naked dorsal seta: hypostoma descending, pubescent, the forehead broad, rather prominent, and pubescent: eyes rounded, small: abdomen elliptical, pubescent, five-ringed.

L. *lucens.* Head nearly round, finely pubescent; antennæ brown: thorax finely pubescent, brownish grey; when seen in certain directions four dark-brown lines are perceptible, the two central ones abbreviated: abdomen oval, pubescent, the colour of the thorax: halteres brown: wing-scales wanting: thighs dark brown: tibiæ and tarsi yellow: wings yellowish brown. Three lines. Inhabits Germany.

Genus Lucina, Meig. Antennæ distant, the third joint ovate, compressed, with a naked dorsal seta at the base: hypostoma descending, naked, and impressed; the forehead broad, somewhat prominent, slightly pubescent, the vertex setose: eyes rounded, small; abdomen flat, oblong, six-ringed: wings longer than the abdomen.

L. *fasciata.* Hypostoma pearly grey, with a silky gloss; forehead ferruginous; antennæ brown: thorax grey, with brownish longitudinal lines, and black spots and bristles; scutellum grey with a black spot: abdomen grey, with a black band on each segment from the second to the fifth, which is widened anteriorly in the middle, and on the second segment there is a longitudinal streak of white: legs reddish grey, the thighs spotted with black: wings somewhat greyish, with two black spots. Three and a half lines. Germany; Marseilles.

Genus Eurina, Meig. Antennæ distant, short, the third joint ovate, compressed, with a naked dorsal seta: head trigonate, pubescent, hypostoma reclined; forehead broad, flat, rather prominent: eyes small and rounded: abdomen oblong, six-ringed; wings incumbent, longer than the abdomen.

E. *lurida.* Forehead ferruginous; hypostoma whitish; antennæ ferruginous at the base, the third joint entirely brown on the outside, the inside yellow with a brown apex: thorax and scutellum dark brown with deep punctures; abdomen and also the legs ferruginous: halteres white: wings somewhat clouded with brown. Two lines. Examples of this insect are preserved in Baumhauer's collection. Its native country is unknown.

Genus Orygma, Meig. Antennæ small, distant, deflexed, the terminal joint ovate, compressed, with a naked dorsal seta at the base: hypostoma reclined, naked: the forehead broad, flat, and setose: eyes rounded, small: abdomen elliptical, villose, six-ringed: legs strong.

O. *luctuosa.* Forehead black and bristly; hypostoma shining ferruginous, the antennæ of a similar colour: thorax flat and bristly: abdomen elliptical, covered with strong hairs; legs ferruginous and pubescent: halteres uncovered, the wings somewhat brownish. Three lines. Meig. *Zw.* vi. pl. lv. fig. 17. Taken by Dr Leach in the neighbourhood of London.

Genus Camarota, Meig. Antennæ porrect, small, the third joint oblong, obtuse, with a thick villose dorsal seta at the base: hypostoma reclined, naked: forehead wide, flat, somewhat arched anteriorly, pubescent: eyes transversely elliptical: wings incumbent, arched.

C. *flavitarsis.* Hypostoma white; forehead ferruginous and finely pubescent; antennæ black: thorax metallic black, covered with small depressions, and marked with two longitudinal furrows behind: abdomen black: legs of a similar colour, the apex of the tibiæ and the tarsi yellow: halteres dark brown, uncovered: wings brownish grey. Found in Germany, at Paris, and near Marseilles.

Genus Cœlopa, Meig. Antennæ small, the terminal joint small and rounded, with a naked dorsal seta at the base: hypostoma excised, villose, the mouth rather prominent; forehead flat, wide, setose: eyes somewhat rounded: abdomen oblong, setose, five-ringed: wings incumbent, longer than the abdomen.

C. *frigida.* Hypostoma thickly covered with hair, the forehead black and thickly covered with bristles; antennæ ferruginous: thorax bristly, and of a black colour: abdomen black, that of the male thickly pubescent and truncated, that of the female pointed and bristly: halteres white, uncovered; wings somewhat greyish: legs reddish brown, thickly covered with hair. Two lines. *Musca frigida*, Fab. This insect is found in Lapland and the most northern countries of Europe.

Genus Sciomyza, Meig. Antennæ somewhat distant, small, obliquely deflexed, the third joint oblong, obtuse, with a dorsal seta at the base, which is either plumose, or pilose, or naked: hypostoma descending or reclined, the forehead broad, setose, or villose: eyes rounded: abdomen oblong, flat, shortly setose, five-ringed: wings incumbent, longer than the abdomen.

S. *simplex.* Shining ferruginous, except the thorax and the last four joints of the tarsi, which are dark brown: the abdomen is marked with a brown longitudinal line: halteres white, the wings somewhat brownish. Three lines. This genus contains twenty-nine species, none of which have been yet detected in Britain.

Genus Dacus, Meig. Antennæ deflexed obliquely, as long as the hypostoma, the third or terminal joint narrow, elongate, obtuse, compressed, with a naked dorsal seta at the base: hypostoma perpendicular, naked, the forehead broad, somewhat setose: abdomen naked, four-ringed.

D. *Oleæ*. Antennæ ferruginous: thorax cinereous on the back, with three longitudinal lines of black, the sides ferruginous anteriorly, black behind; the shoulders, a small spot at the base of the wings, and another of an elliptical form beneath them, sulphur-yellow; the scutellum of the same colour: abdomen rufous, with three interrupted black bands: legs rufous: halteres white: wings hyaline, having a dark-brown spot at the apex. Two lines. Inhabits Germany, France, and Italy.

Genus Platycephala, Meig. Antennæ projecting obliquely, rather remote, the two terminal joints equal, the third with a naked dorsal seta at the base: hypostoma reclined, naked, the forehead flat, broad, naked: eyes rounded: wings incumbent, longer than the abdomen, the transverse nerves approximating on the disc.

P. *umbraculata*. Forehead ferruginous, with a black impression in the middle; hypostoma likewise ferruginous; antennæ with the first and second joints black, the third ferruginous, the apex black and the seta white: thorax ferruginous, marked with three broad vittæ of a dark-brown colour on the upper side: abdomen wholly dark brown, ferruginous on the under side: legs ferruginous: wings greyish. Two lines. *Musca umbraculata*, Fab. Only three species have been described as pertaining to this genus. The one described above, and *P. planifrons*, have been found in Britain. *P. nigra* occurs in Germany and France.

Genus Sepedon, Lat. Antennæ porrect, longer than the head, the second joint elongate, compressed, setose; third acute, emarginate above, and having a naked dorsal seta at the base: hypostoma perpendicular, descending, naked, the forehead broad and somewhat prominent: eyes rounded and rather prominent: abdomen elongate, five-ringed, naked: hinder thighs thick and spinose beneath: wings incumbent.

S. *sphegeus*. Shining bluish black; antennæ dark brown, the seta black above, white beneath; eyes green, with a dark purple fascia: thorax cinereous, with two dark lines along the back; the sides shining metallic black: halteres white: wings brownish yellow, unspotted; legs bright ferruginous. Three lines. *Sepedon palustris*, Lat. Found during the summer in various parts of the continent, and in England, but is nowhere common.

Genus Dorycera, Hoff. Antennæ remote, the length of the head, the second and third joints equal in length, second linear, compressed, and setose; third conical, ventricose at the base, and furnished with a naked seta on the back: hypostoma reclined, arched, and naked; forehead flat, somewhat prominent, villose, and flat: eyes rounded and a little prominent: abdomen oblong, five-ringed, the style of the female jointed: wings incumbent, longer than the abdomen.

D. *graminum*. Hypostoma shining ferruginous, spotted with black; forehead ferruginous, with two black lines and a white ring round the eyes: antennæ ferruginous, black at the apex: thorax grey, with six black lines; scutellum grey, spotted with black on the sides: abdomen blackish, inclining to reddish brown in the female, and having a pale interrupted line on the back: legs ferruginous, with brown tarsi: halteres bright yellow: wings greyish. Four lines. *Musca graminum*, Fab.; *Tetanocera graminum*, Lat. Inhabits France; apparently not found in Britain.

Genus Tetanocera, Dum. Antennæ porrect, remote, the second joint compressed and setose, third excised on the upper side, compressed, with a plumose or naked dorsal seta: hypostoma descending (rarely reclined) furrowed, naked; the forehead broad and setose: eyes rounded and somewhat prominent: abdomen oblong, five-ringed, somewhat setose: wings incumbent, projecting beyond the abdomen.

T. *Hieracii*. Hypostoma and palpi white; forehead ferruginous, without impressions, with brown spots on the crown, and four black points at the margin of the eyes: antennæ rufous: thorax bright yellow, finely shagreened, and covered with black spots: scutellum yellow, with a black spot: abdomen bluish grey, with three confluent deep-black spots on each segment: legs bright yellow, the apex of the hinder thighs spotted with black: halteres white; wings white, variegated with dark brown. Two lines. *Tephritis Hieracii*, Fab.; Meig. *Zw.* vi. pl. lvii. fig. 18. Not unfrequent in summer among grass. It is found in Britain, along with eleven other species.

Genus Heteromyza, Meig. Antennæ porrect, somewhat remote, the third joint orbicular, compressed, with a naked dorsal seta: hypostoma descending, perpendicular, furnished with a mystax: forehead broad and setose: eyes rounded: abdomen oblong, five-ringed: wings longer than the abdomen, the rib without bristles.

H. *atricornis*. Hypostoma white, with a longitudinal furrow on each side: forehead rufous, having a white ring round the eyes; the crown and hinder part of the head bluish grey; palpi rufous: antennæ deep black, furnished with a long seta: thorax and scutellum bluish grey: abdomen and legs rufous. Three lines. Meig. *Zw.* vi. pl. lvii. fig. 21. Meigen describes four species of Heteromyzæ, of which the only one hitherto detected in England is *H. buccata*, Fallen. No locality is cited for *H. atricornis*.

Genus Helomyza, Meig. Antennæ somewhat deflexed, remote, the third joint oblong or orbicular, having a plumose or naked dorsal seta at the base: hypostoma perpendicular, descending, furnished with a mystax; forehead wide and setose: eyes rounded: abdomen oblong, six-ringed: wings incumbent; the costa setose.

H. *rufa*. The male is ferruginous, with black bristles; the third joint of the antennæ is elliptical, and bears a long plumose seta: abdomen with black bands, which are widened in the middle: hinder knees and two last joints of the tarsi black: wings somewhat brownish, with two white marginal spots at the apex. This species has been found in England by Dr Leach. *H. ustulata*, figured by Curtis (*B. E.* fol. 66), and by Meig. (*Zw.* pl. lvii. fig. 30), is also a native of Britain.

Genus Dichæta, Meig. Antennæ distant, somewhat deflexed, short, the third or terminal joint oblong, compressed, having a pectinated dorsal seta at the base: hypostoma somewhat descending, convex, setose; the forehead wide, setose: eyes rounded: abdomen ovate, five-ringed, that of the male with long setæ at the apex: wings incumbent; the transverse nerves remote.

D. *caudata*. Hypostoma brownish yellow; forehead dark grey; two lower joints of the antennæ brown, the third bright yellow: body dark grey, somewhat bristly; thorax with three broad lines of black: legs dark grey, the tarsi yellow: halteres white: wings greyish. Two lines. A rare insect on the continent. According to Curtis, it has occurred in Britain.

Genus Notiphila, Meig. Antennæ somewhat remote, deflexed, short, the third joint oblong or orbicular, compressed, with a pectinated dorsal seta at the base; hypostoma somewhat descending, rather naked, convex; the forehead broad, setose: eyes rounded: abdomen rather flat, ovate or oblong, five-ringed: wings incumbent, longer than the abdomen; the transverse nerves remote.

N. *cinerea*. Hypostoma fulvous, without lustre, furnished with short bristles on each side of the eyes, which are surrounded with a whitish ring: forehead, thorax, and scutellum ferruginous; on the thorax there are six rows of small tubercles of a black colour: antennæ brown, the third joint yellow at the base: abdomen cinereous, with three black spots on both sides: legs ferruginous, with black thighs: halteres white: wings nearly hyaline. One line and a half. During spring and summer very common in some countries on the *Equisetum palustre*. It occurs in Britain, but does not seem common.

GENUS DISCOMYZA, Meig. Antennæ deflexed, short, third joint oblong, compressed, obtuse, with a pectinated dorsal seta at the base: hypostoma short and rugose; forehead broad, short, and naked: eyes oblong: abdomen depressed, suborbicular, naked, four-ringed: wings deflexed, the length of the abdomen.

D. *incurva*. Black and glossy, the tarsi yellow: halteres small and white: wings somewhat greyish, the anterior margin brown. One line and a half. Meig. *Zw.* vi. pl. lviii. fig. 16, 17. Inhabits Austria and other parts of the continent.

GENUS OCHTHERA, Lat. Antennæ incumbent, short, the third joint elliptical, compressed, with a pectinated dorsal seta at the base: hypostoma descending, naked, convex, coarctate at the apex; forehead broad, impressed, naked: eyes rounded and somewhat prominent: abdomen flat, elliptical, naked, five-ringed: anterior thighs swollen, and spinose beneath: wings incumbent, the fourth longitudinal nerve recurved at the apex.

O. *Mantis*. Hypostoma brownish, with a white play of colour; forehead black: body naked, black, with a metallic lustre, the thorax marked with three black lines; abdomen with a small white spot on each side of the second, third, and fourth incisures: legs black: halteres white: wings somewhat cinereous. Two lines. *Musca manicata*, Fab. Found in August and September.

GENUS STEGANA, Meig. Antennæ incumbent, the third joint oblong, obtuse, compressed, with an irregularly plumose dorsal seta at the base: hypostoma somewhat impressed, and furnished with a mystax; forehead broad and setose: eyes oblong: abdomen oblong, six-ringed: wings longer than the abdomen, incurved, deflexed.

S. *nigra*. Hypostoma and forehead ferruginous, the latter bristly; antennæ yellow: body shining black, somewhat bristly; legs yellow, the hinder thighs brownish: halteres yellow: wings smoke colour. One line and a fourth. Meig. *Zw.* vi. pl. lviii. figs. 24, 25. *Drosophila curvipennis*, Fallen. A scarce insect on the continent, and not occurring at all in Britain.

GENUS DROSOPHILA, Meig. Antennæ incumbent, the third joint oblong, obtuse, compressed, with an irregularly plumose dorsal seta at the base: hypostoma with a mystax, the forehead broad and setose; eyes rounded: abdomen oblong, six-ringed: wings incumbent, longer than the abdomen.

D. *funebris*. Hypostoma and forehead rust-brown: antennæ dark brown, the base yellow: thorax shining testaceous: abdomen shining black, each of the incisures behind with a rather broad yellow band: legs ferruginous: wings rather obscured with brown, but not spotted. One line and a half. *Musca funebris*, Gmel.; *Musca cellaris*, Linn. Found during spring and summer occasionally.

GENUS ASTEIA, Meig. Antennæ deflexed, the terminal joint patelliform, with an irregularly pectinated dorsal seta at the base: hypostoma naked; the forehead broad, and somewhat setose: eyes rounded (fasciated): abdomen naked, five-ringed: wings incumbent, large; the ordinary transverse nerve wanting.

A. *concinna*. Straw colour, the hypostoma with two black spots, and two black longitudinal streaks on the crown: thorax shining black, pale round the outer side, the sides and breast straw-colour: scutellum straw-colour, with a black spot at the base; abdomen and legs entirely straw-colour; wings large and hyaline. One line. Both this and the only other species of the genus, *A. amœna*, occur in England.

GENUS OCHTHIPHILA, Meig. Antennæ deflexed, the terminal joint oblong, compressed, obtuse, with a naked dorsal seta at the base: hypostoma nearly naked; the forehead broad and setose: eyes rounded: abdomen oblong, five-ringed: wings incumbent.

O. *Juncorum*. Light cinereous: antennæ yellow, with the apex black; the abdomen with two rows of black spots: thighs grey; the apex, tibiæ, and first joint of the tarsi bright yellow, the four other joints brown: wings hyaline. One line. Meig. *Zw.* vi. pl. lix. fig. 11. Common in Germany. None of the species, which are seven in number, have been detected in Britain.

GENUS DIASTATA, Meig. Antennæ incumbent, the terminal joint compressed and obtuse; have a dorsal seta at the base, which is densely plumose or naked: hypostoma with a mystax: the forehead broad and setose: eyes somewhat rounded: abdomen oblong, five-ringed: wings incumbent, longer than the abdomen, the transverse nerves remote.

D. *obscurella*. Hypostoma whitish; antennæ and forehead rufous, the margin of the eyes and the crown light grey; the third joint of the antennæ brown at the apex: thorax cinereous: abdomen black, with some lustre: legs rufous: halteres white. One line. Meig. *Zw.* pl. lix. fig. 15. Rather scarce: not indigenous to this country.

GENUS OPOMYZA, Meig. Antennæ deflexed, the terminal joint ovate and compressed, having a dorsal seta at the base, which is shortly plumose or pubescent: hypostoma naked, or furnished with an imperfect mystax; the forehead broad and setose: eyes rounded: abdomen elongate, six-ringed: wings incumbent.

O. *combinata*. Palpi and proboscis white; head, antennæ, thorax, and legs rather bright shining rufous: abdomen of the males linear, shining black, rufous at the base; that of the female more elliptical, flat, rufous, with black bands at the incisures: halteres white: wings small, hyaline, the cross nerves and a spot at the apex dark brown. One line and a third. *Tephritis combinata*, Fab. Inhabits Britain and Germany.

GENUS EPHYDRA, Fallen. Antennæ deflexed, the terminal joint oblong, compressed, and obtuse, with a naked dorsal seta at the base: hypostoma arched or convex, villose; the forehead broad and setose: eyes rounded, somewhat prominent: abdomen elliptical, depressed: wings incumbent, longer than the abdomen.

E. *palustris*. Hypostoma brownish black, setaceous, at least about the mouth; forehead dark green, shining: antennæ black, with a rather thick seta: body shining dark green: scutellum arched: halteres white: wings pale brown: legs black. One line. Found in marshy places.

GENUS HETERONEURA, Meig. Antennæ porrect, the second joint the same length as the third, the latter orbiculate, with a pubescent seta inserted in the middle of the back; forehead flat, furnished with a mystax; the forehead broad and setose: eyes rounded: abdomen elongate, five-ringed; wings incumbent, the transverse nerves approximating in the middle of the disc.

H. *nubila.* Hypostoma and forehead ferruginous, with a whitish lustre round the margin of the eyes; antennæ ferruginous, the third joint somewhat brownish: thorax shining ferruginous, passing into brown, with four dark-brown lines on the back, and a white one on the sides, reaching to the base of the wings; the sides ferruginous: abdomen black: legs rufescent: halteres white: wings somewhat greyish. Male one and a half, female nearly two lines. Inhabits Austria and other European countries.

Genus Gitona, Meig. Antennæ incumbent, the terminal joint elliptical, compressed, having a naked dorsal seta at the base: hypostoma carinated in the middle, and provided with a mystax; the forehead broad and setose: eyes rounded: abdomen ovate, flat, five-ringed: wings incumbent, longer than the abdomen; the transverse nerves approximating.

G. *distigma.* Hypostoma, palpi, and antennæ rufous; forehead of a similar colour, with two brown lines; thorax setaceous, light grey, with three dark somewhat undulating lines: scutellum light grey or yellowish: abdomen shining rufous, with four bands and a dorsal line of black: legs and halteres rufous; wings hyaline. Two lines. Meig. *Zw.* vi. pl. lx. fig. 19. Found in the south of France, and elsewhere.

Genus Milichia, Meig. Antennæ porrect, the terminal joint patelliform, with a naked dorsal seta at the base; hypostoma impressed, and provided with a mystax; the forehead broad and setose; eyes rounded: abdomen ovate, four-ringed: wings incumbent, longer than the abdomen.

M. *speciosa.* Male. Hypostoma white, setaceous about the mouth and sides; palpi black and pubescent; forehead slate-grey with a white play of colour, and when seen in some directions two brownish lines are perceptible: antennæ black: thorax greyish white: scutellum black: abdomen shining silver-white; the belly, halteres, and legs, black: wings hyaline, the anterior edge brown from the middle to the apex. Two lines. Meig. *Zw.* pl. lx. fig. 23. Has been taken near Marseilles, and in Provence.

Genus Leucopis, Meig. Antennæ porrect, the third joint patelliform, with a naked dorsal seta at the base: hypostoma somewhat impressed, naked; the forehead broad and naked: eyes rounded: abdomen ovate, five-ringed, depressed: wings incumbent, longer than the abdomen.

L. *griseola.* White with a bluish tinge; antennæ deep black: thorax with four pale-brown lines, the central one narrowest: abdomen with a black play of colour at the base, and marked with two black dots: halteres white: wings hyaline, with brown nerves: thighs grey, the apex yellow; the tibiæ and tarsi rufous, the former encircled with a pale-brown ring. One line. *Anthomyza griseola*, Fallen; Meig. *Zw.* vi. pl. lx. fig. 28. Found on the continent, but the special localities are not mentioned.

Genus Gymnopa, Meig. Antennæ incumbent, the third or terminal joint somewhat oblong, compressed, and obtuse, with a naked dorsal seta at the base: hypostoma descending, naked, tuberculated; the forehead broad, and nearly naked: eyes rounded: abdomen ovate, glabrous, five-ringed: wings incumbent, longer than the abdomen; the fifth longitudinal nerve abbreviated behind.

G. *subsultans.* Dark metallic green, shining: head and legs black: halteres white. One line and a half. *Syrphus subsultans*, Fab. Found in August and September. The genus contains four species, none of which have been hitherto noticed in Britain.

Genus Chlorops, Meig. Antennæ deflexed, porrect, the terminal joint patelliform, with a naked or pubescent dorsal seta at the base: hypostoma descending, naked; forehead broad and pubescent: eyes rounded: abdomen elliptical, naked, five-ringed: legs simple: wings incumbent, the transverse nerves approximating on the disc.

C. *gracilis.* Straw-colour, as well as the antennæ and legs: forehead rufous: thorax marked with three dark-grey lines, of which the central one is abbreviated behind, and the others in front; and on each side of the breast there is a black spot; there is also a black spot on each side of the first incisure of the abdomen. Three lines. *Meig. Zw.* vi. pl. lxi. fig. 17. Has been taken near Paris on the flowers of *Chrysanthemum leucanthemum*, in Russia, and in Austria. The genus is composed of sixty species, all of them minute insects; and a considerable number appear to inhabit Britain.

Genus Meromyza, Meig. Antennæ deflexed, porrect, the third or terminal joint nearly patelliform, with a naked dorsal seta at the base; hypostoma descending, naked; the forehead broad, rather prominent and pubescent; eyes rounded and somewhat prominent: abdomen conical, naked, five-ringed: hinder thighs thickened: wings incumbent, the transverse nerves approximating in the middle of the disc.

M. *pratorum.* Pale-greenish yellow, as well as the antennæ and legs; hinder part of the head unspotted: thorax with three greenish-grey lines, the central one running along the scutellum also; abdomen, with an interrupted dorsal line of black, and a black spot on each side at the base. Two lines. Meig. *Zw.* vi. pl. lxi. fig. 25. Inhabits Germany and Britain.

Genus Agromyza, Fallen. Antennæ deflexed and porrect, the third joint orbicular, with a naked dorsal seta at the base: hypostoma with a mystax; the forehead broad and setose: eyes rounded: abdomen five-ringed: wings incumbent, longer than the abdomen, the transverse nerves approximating.

A. *denticornis.* Head yellow, with a black point on the crown; antennæ black, with a yellow base; the third joint having a small horn before the apex: thorax with a yellow streak on the sides: scutellum yellow: halteres white: legs black, with yellow thighs. One line. Meig. *Zw.* vi. pl. lxi. figs. 33, 34. *Chlorops denticornis*, Panzer; *Chlorops Meigenii*, Fallen. Found in England and on the continent. The genus is extensive, comprehending sixty-nine species. Few of these have been detected in this country, although there can be little doubt that a large proportion inhabit Britain.

Genus Phytomyza, Fallen. Antennæ porrect, the terminal joint patelliform, with a naked dorsal seta: hypostoma with a mystax; forehead broad and setose: eyes rounded: abdomen elongate, six-ringed: wings incumbent, longer than the abdomen, the transverse nerves placed at the base of the wings, the ordinary one generally wanting.

P. *flavicornis.* Blackish; thorax and scutellum dark grey; antennæ entirely yellow: halteres white: wings somewhat grey: the incisures of the abdomen and the legs yellow. Two thirds of a line. Meig. *Zw.* vi. pl. lxii. fig. 6. Found on the continent, but is not common.

Genus Therina, Meig. Antennæ porrect, the third joint patelliform, with a long naked dorsal seta at the base: hypostoma impressed, and furnished with a mystax; the forehead broad and pilose: eyes rounded: abdomen oblong, five-ringed: wings incumbent, the transverse nerves remote.

T. *femoralis.* Hypostoma ferruginous, forehead of the same colour anteriorly, grey behind; antennæ black: thorax dark grey, with four rather indistinct dark lines: abdomen black: halteres white: wings hyaline: legs ferruginous; the anterior thighs thickened. Scarcely one line. Found on the continent.

Genus Borborus, Meig. Antennæ porrect, the terminal joint sphæroidal, with a naked dorsal seta: hypostoma impressed, and furnished with a mystax; forehead broad, setose, declined: eyes rounded: abdomen flat, five-ringed: hinder metatarsi abbreviated and thickened: wings incumbent, longer than the abdomen (or wanting).

B. *clunipes.* Hypostoma and anterior part of the forehead testaceous: body dark brown: scutellum elongate, flat, setaceous: halteres brown: wings hyaline: the two first joints of the hinder tarsi thickened, the second somewhat longer than the first. One half line. Found in dung; but is rare. It occurs in England.

FAMILY XXIV.—TRINEURÆ.

Genus Phora, Lat. (Plate CCXXXVIII. fig. 30.) Antennæ inserted at the opening of the mouth, globose, with an elongate erect naked seta; palpi exserted, clavate, setose: abdomen six-ringed: hinder legs elongate: wings incumbent.

P. *incrassata.* Black, the forehead tuberculated: palpi and antennæ black: the first incisure of the abdomen margined with white: legs black, the anterior pair with the apex of the thighs, the tibiæ, and tarsi, ferruginous: halteres brown: wings nearly hyaline, somewhat brownish. One and a half line. In September; not rare.

Genus Conicera, Meig. Antennæ erect, conical, with a naked terminal seta: palpi exserted, setose: abdomen six-ringed: wings incumbent.

C. *atra.* Velvet black; forehead pitch-brown; anterior tibiæ and tarsi rufous; wings clear hyaline. Half a line. Found in September; but nowhere common. Apparently not indigenous to Britain.

DIVISION II.—EPROBOSCIDEÆ.[1]

FAMILY CORIACEÆ.

Genus Hippobosca, Linn. (Plate CCXXXVIII. figs. 31 and 31 *a.*) Antennæ gemmiform, inserted into the sides of the hypostoma, and having a naked apical seta: ocelli wanting: the tarsi with equal bidentate claws: wings parallel, incumbent, obtuse, with many nerves.

H. *equina.* Forehead and hypostoma shining ferruginous: eyes pitch-brown: thorax shining dark brown, the shoulders ferruginous; before the scutellum there are three yellow spots, of which the central one forms an acute triangle: scutellum yellow, with black spots on the sides: abdomen pubescent, brownish grey: legs ferruginous, the thighs and tibiæ of the middle pair with a dark ring, the hinder pair with two: halteres black: wings brownish, the marginal nerves dark brown. Four lines. Linn. Fab. On horses and cattle.

We are still indebted to Réaumur for the greater part of our knowledge regarding the very singular mode of production in the genus Hippobosca, or forest-flies, as these insects are sometimes called. That delightful observer has named them *Mouches Araignées.* The larva is hatched and nourished within the body of the mother, and remains there till after its transformation to the nympha state. Hence the term *pupiparous*, as applied to the Hippoboscæ and other genera of the tribe. The nymph, or rather cocoon, is at first of a milky whiteness, with a large plate (plaque) at one end, black and shining, like ebony. It is of a round and flattened form, emarginate at the plated end, where it forms two rounded or horn-like eminences. It becomes entirely black soon after exclusion, and the skin or covering, of a cartilaginous or scaly texture, resists a strong pressure of the fingers, and is even difficult to cut with the sharpest scissors. The body of the mother scarcely equals the dimensions of the nymph, and it has often been a subject of marvel how the greater should proceed from the less. It appears, however, that the cocoon is possessed of an expansive power, which is probably exercised the moment after its exclusion from the body of the parent. The hardness and solidity of the skin, though well qualified to defend the nymph from injury, might seem to present a serious obstacle to the escape of the perfect insect. But nature, so complete and bountiful in all her doings, and so pervaded even in her minutest operations by the perfect wisdom of her great Author, has provided against this seeming inconvenience by a beautiful contrivance. When we examine the larger end by means of a microscope, we shall perceive the feeble trace of what in fact constitutes a kind of cap or cowl, and which may sometimes be made to spring off even by the touch of a penknife. When the perfect insect is ready for exclusion, it finds it an easy matter to manage this piece of natural mechanism. The coriaceous envelope to which we have alluded is, in fact, the distended and somewhat altered skin of the larva, and within it Réaumur succeeded in detecting the exuviæ of the nymph. The phenomena of transformation are, therefore, so far analogous to what we observe in the coarctate pupæ of some other dipterous tribes, and the chief anomaly consists in the larva passing the entire period of its existence within the body of the mother, and being *born* in the pupa state.[1]

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[1] In our copy of Meigen's *European Diptera*, the work by which we have been guided in the systematic portion of our exposition of the order, there is (at page xxxiii. of the first volume) a brief exposition of the characters of Division I. Proboscideæ. This we have given at page 258 of the present treatise. In the sixth and last volume of the German author we do not, however, find any indication of Division II. Presuming, nevertheless, from the strong disparity of character presented by the Coriaceæ, when compared with the preceding families, that they must constitute the other principal branch of the dipterous order, we have applied the name of Eproboscideæ, as significative of the division sought for. It was so applied by Latreille (*Gen. Crust. et Insect.* t. iv. p. 360), as well as (excepting *Nycteribia*) by Dr Leach (*Wernerian Memoirs*, vol. ii. p. 547), to the family in question. The species of which it is composed are in truth of a very singular structure and economy, and altogether of a nature so anomalous, as to cause some doubts as to their proper position in the system. They are now regarded as constituting a separate order, under the name of Homoloptera, by Leach, Macleay, Stephens, and other English naturalists, and form the family Pupipara of Latreille. Some contrariety of opinion still exists regarding the structure of the mouth. We shall here satisfy ourselves by a quotation from the last-named entomologist, to whom we have been already so deeply indebted. "La tête de ces insectes, vue en dessus, est divisée en deux aires ou parties distinctes, dont l'une postérieure et principale, ou composant plus spécialement la tête, porte les yeux, et reçoit, dans une échancrure antérieure, l'autre partie. Celle-ci se partage aussi en deux, dont la postérieure plus grande et coriace porte latéralement les antennes, et dont l'autre constitue l'appareil manducateur. La cavité inférieure et buccale de la tête est occupée par une membrane; on voit sortir de son extrémité un suçoir, naissant d'un petit bulbe ou pédicule avancé, composé de deux filets ou soies très rapprochés, et recouvert par deux lames coriaces, étroites, alongées et velues, qui lui font l'office de gaîne. Que ces lames ou valvules représentent, ainsi que je l'ai présumé, les palpes des autres diptères, ou qu'elles soient les pièces d'une gaîne proprement dite, comme le pense M. Dufour, à l'occasion d'une espèce d'ornithomyie (*Annales des Scienc. Nat.* x. 243, xi. 1), où il a decouvert deux petits corps, qu'il prend pour des palpes, il n'en serait pas moins vrai, que la trompe de ces insectes differerait sensiblement de celle des diptères précédents, et que la gaîne, dans ce cas, aurait plus de rapports avec celle de la trompe de la puce, dont elle s'éloignerait cependant par l'absence d'articulations. (*Règne Animal*, t. v. p. 538.)

Genus Ornithobia, Meig. Antennæ small, immersed, inserted on the sides of the hypostoma, papillary, naked: ocelli wanting: tarsi with unequal bidentate claws: wings parallel, incumbent, with three nerves.

O. pallida. The colour of the head is ferruginous; the proboscis of a similar colour, shorter than the head: thorax flat, rounded, shining black, with a rather large ferruginous spot on each shoulder, and two lines of the same colour in the middle; the hinder part setaceous, at least on the sides; scutellum transverse, ferruginous, the hinder margin bristly: halteres white: abdomen ferruginous, oval, pubescent: wings nearly hyaline, with pale nerves: legs ferruginous, pubescent, robust: the first four joints of the tarsi very short, the fifth longer, with two long unequal claws, the outer claw shorter than the interior one. Two lines. Rare; apparently not found in Britain.

Genus Ornithomyia, Lat. Antennæ gemmiform, setose, inserted into the sides of the hypostoma; vertex with three ocelli; tarsi with tridentate claws: wings incumbent, obtuse.

O. avicularia. Greenish yellow: antennæ and proboscis ferruginous; eyes pitch-brown: thorax blackish on the sides, with a yellowish longitudinal line: wings smoke colour with dark-brown nerves, the longitudinal nerves not very distinct: legs pubescent. Two to two and a half lines. *Hippobosca avicularia*, Linn. Degeer, vi. 114, pl. xvii. fig. 21–27. These insects occur on different species of birds, but never on quadrupeds,—a fact in their history which, in connection with the difference of structure, renders their generic separation from Hippobosca the more advisable. Latreille thinks that their metamorphoses resemble those of the last-named genus. The species above described is extremely vivacious, runs swiftly, sometimes side foremost like a crab, and flies with considerable facility.

Genus Stenopteryx, Meig. Antennæ gemmiform, setose, inserted into the sides of the hypostoma: vertex with three ocelli: tarsi with tridentate claws: wings very narrow, acute, longer than the abdomen.

S. hirundinis. This species is very closely connected with those of the preceding genus, differing chiefly in the long, narrow, pointed wings: the colour is ferruginous, with pitch-brown eyes: the antennæ are covered with long black setæ. Two lines. *Hippobosca hirundinis*, Linn.; *Stenepteryx hirundinis*, Leach; *Ornithomyia hirundinis*, Lat. Meig. *Zw.* vi. lxiv. fig. 5. Found on different kinds of swallows, especially the *Hirundo Apus* of Linn. The wings of this species are not well adapted for flight. Réaumur once found as many as thirty in a swallow's nest.

Genus Anapera. Antennæ gemmiform, setose, inserted into the sides of the hypostoma: ocelli wanting: tarsi with tridentate claws: wings short and acuminated.

A. pallida. Ferruginous; the abdomen brown: antennæ with numerous long black hairs: thorax rhomboidal, the anterior part embracing the head on both sides; sinuated on each side, but widened in the middle, and the back impressed with a deep longitudinal line: the hinder part setaceous, especially towards the sides: scutellum transverse: legs robust, especially the thighs, and covered with long hair: wings short, scarcely longer than the abdomen, somewhat greyish, with ferruginous nerves, the apex acute. Two and a half lines. *Ocypterum pallidum*, Leach; *Mouche-araignée*, Geoff. *Ins.* ii. 547, 2. Found on swallows, especially the swift.

Genus Melophagus, Lat. Antennæ papillary, immersed, inserted in the sides of the hypostoma: eyes linear and small: ocelli wanting: tarsi with bidentate claws: wings wanting.

M. ovinus. Ferruginous; the abdomen brown; forehead wide, with the crown smooth and without ocelli, the other parts setaceous: proboscis as long as the head, and porrected: thorax embracing the head anteriorly: abdomen oval: legs robust, pubescent; the tarsi short, with bidentate claws. Two lines. *Hippobosca ovina*, Linn. Found in considerable numbers among the wool of sheep. Another species occurs upon the stag.

Allied to the preceding genus is that named Braula by Dr Nitzsch. The only known species lives upon the honey-bee, and is figured by Germar.[2] It is absolutely blind.[3]

Genus Nycteribia.

We shall conclude this lengthened exposition of the dipterous order by a few observations on the genus Nycteribia of Lat., *Phthiridium* of Hermann, concerning the true position of which very various opinions have been entertained. The species are in fact entirely apterous, having neither wings nor halteres. They bear a general resemblance to spiders. The head is extremely small, and as it were implanted on the anterior and dorsal portion of the thorax, in the form of a little capsular tubercle. The eyes seem composed of minute grains. The thorax is semicircular. Even Latreille (in his earliest work) was so far misled by the anomalous aspect of these insects as to mistake the very Class to which they belonged. He consequently placed them among the Arachnides. In this he was followed by Dr Leach,[4] who was probably not aware that the great French entomologist had long before rectified his error. When a species of the genus was first observed on a bat by Colonel Montagu, he thought it an entirely new insect, and named it, on account of its rapid movements, *Celeripes Vespertilionis.*[5] It appears, from an expression in the *Fauna Suecica*, that Linnæus described it as a *Pediculus*. The generic name of *Phthiridium*, bestowed by Hermann the younger,[6] being posterior in date to that of Latreille, ought not to be adopted. We may add, that the antennæ, which the German author did not observe, and which he stated did not exist, have been detected by Latreille.[7] They are extremely short, advanced, bi-articulate, and inserted close to each other, on the emargination of the upper edge of the head. The eyes are placed immediately beneath them.

These curious insects, as far as yet known, occur on bats, over which they move with great rapidity; but when withdrawn from their natural nidus they become quite confused, and almost incapable of locomotion. Their heads being placed as it were upon their dorsal aspect, it was difficult to understand how they satisfied their appetite; and we owe to Colonel Montagu the observation, that when they suck the blood of bats they place themselves in a reverse position on their backs. Of the few species known, two are found in Britain, on the greater and the lesser horse-shoe bats. Another species occurs in the Isle of France.[8]

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[1] For a detailed account of the internal structure of these insects, see M. Dufour's *Recherches Anatomiques sur l'Hippobosque des Chevaux*, in the *Ann. des Sciences Nat.* t. vi. p. 299. For their classification, and that of the allied genera, consult Dr Leach's *Insecta Eproboscidea*, in *Memoirs of the Wernerian Society*, vol. ii. p. 547; and *Règne Animal*, t. v. p. 543.

[2] *Fauna Insect. Europ.* vi. 25.

[3] *Règne Animal*, t. v. p. 545.

[4] In the *Supplement* to the preceding edition of this Encyclopædia, vol. i. p. 446. See also *Zool. Miscell.* vol. iii. p. 55.

[5] *Linn. Trans.* vol. ix. p. 166, note.

[6] *Mém. Aptérologique*, p. 124.

[7] *Nouv. Diction. d'Hist. Nat.* art. *Nyctéribie.*

[8] *Diction. Class. d'Hist. Nat.* t. xii. p. 25.

ORDER IX.—SUCTORIA, DEGEER.[1]

In this order the mouth consists of a sucker of three parts (two maxillæ and a ligula), contained between two articulated blades (the labium), forming by their union a trunk or beak, cylindrical or conical, and covered at the base by a pair of scales, supposed to represent the palpi. The species undergo a genuine metamorphosis analogous to that of several Diptera, such as the *Tipulariæ* of Latreille.

The genus PULEX of Linnæus composes the entire order. The body is oval, compressed, covered by a tough integument, and divided into twelve segments, of which the anterior three constitute a short thorax, and the remainder the abdomen. The head is small, much compressed, rounded above, truncated and ciliated in front, and furnished on each side with a little circular eye, behind which, and lodged in a groove, we find certain small moveable articulated bodies, which are the true antennæ. Towards the anterior part of the head, and near the origin of the sucker, are placed another pair of appendages, which Latreille and others have regarded as the antennæ, but which are now with greater propriety considered as maxillæ, or parts of the mouth. Between these is placed the sucker, composed of a bivalvular articulated sheath, and three setæ. The sheath, according to Dugès, corresponds to the labial palpi, while two of the setæ represent the mandibles, and the remaining one is regarded as the analogue of the ligula.

In regard to the species,—"Chacun," says Latreille, "connait la Puce commune." In this country we call it *flea;* and, presuming that it is nearly as well known here as in France, we shall not trouble our readers with a detailed description. The female lays about a dozen eggs, of a white colour, and slightly viscous. From these ere long proceed little lively worms, which move like serpents, or roll themselves about spirally, or in circles. They are at first white, but become ere long of a reddish hue, and are composed of a scaly head, without eyes, furnished with two minute antennæ, and of numerous segments bearing little tufts of hair, and two hooks at the caudal extremity. The mouth exhibits some small moveable pieces, of which the larva makes use in pushing itself forward. They remain about twelve days in that condition, and then each larva encloses itself in a little silk cocoon, where it becomes a nymph, and from which, after about an equal lapse of time, the perfect insect issues forth. The common flea (called by naturalists *Pulex irritans,* see the figure last referred to) occurs in almost all countries. It is parasitical on the bodies of several other animals besides the human kind (of which it prefers children and the gentler sex, owing to the superior softness of their skin), such as dogs, cats, hares, among quadrupeds,—and pigeons, poultry, and swallows, among birds. Defrance, who has published some interesting observations on the eggs and larvæ, has also shown that bathing domestic animals has no effect in ridding them even of the perfect insect, which he has seen resume its wonted functions after a continuous immersion of twenty-two hours. The process, however, is useful, in as far as it appears to annoy the pregnant females, which do not endure immersion above eleven hours. In Dalecarlia the natives place hare-skins in their beds, and other parts of their houses, for the fleas to nestle in. They then destroy them by dipping the skins in hot water, or holding them over a fire.

The genus Pulex is by no means numerous in species. A large yellow kind occurs upon the mole, and a banded species (*P. fasciatus* of Bosc) is found upon the fox. Professor Graham thinks he caught it in Clova. The *Pulex penetrans* of Linn., known to the French colonists of America by the name of *Chique* (Plate CCXXXIX. fig. 14), is by some regarded as belonging to a distinct genus. Its sucker is as long as its body (fig. 14, *b*). It introduces itself beneath the toe nails, or under the skin of the feet, where the female speedily acquires a considerable bulk in consequence of the growth of her eggs (fig. 14, *a*). The numerous young to which these give birth sometimes occasion malignant ulcers, difficult to cure, and occasionally mortal. They are extirpated by using a lavement of tobacco juice, or other acrid infusion. The negroes, from frequent practice, extract them with great skill.[2]

ORDER X.—THYSANOURA, LAT.

The insects of this order, like those of the preceding, are apterous, or without wings. In addition to the usual number of legs, they are provided, either along their sides, or at the extremity of the abdomen, with peculiar organs, which assist the purposes of locomotion. They are masticators, that is, furnished with mandibles and maxillæ. They do not undergo metamorphoses. All the species are of small size, of rather soft consistence, and are generally covered either with shining silvery scales or hairs. They avoid strong light, and seldom quit their retreats till the shades of night have fallen. Some inhabit the interior of houses, keeping themselves concealed in presses, in the interstices of shutters, window-sashes, and other wooden fabrications;—others occur under stones and in humid places. The order is divisible into two families.

FAMILY I.—LEPISMENÆ, LAT.

This family corresponds to the genus *Lepisma* of Linnæus. The antennæ are setaceous, usually very long, and divided from their base into many small articulations. The palpi are distinct and projecting. The abdomen is furnished inferiorly on each side with a range of moveable appendages in the form of false legs, and is terminated by articulated setæ, of which three are more obvious than the others. The body is of an elongated form, and covered with small shining silvery scales. The mouth is composed of a labrum, two almost membranaceous mandibles, a pair of maxillæ, each furnished with a palpus of from five to six articulations, and of a labium of four emarginations, bearing two quadri-articulate palpi. The thorax consists of three perceptible portions. The abdomen, which becomes gradually narrower towards its posterior extremity, is provided, in addition to the false legs just mentioned, with an anal appendage or scaly style, compressed, and composed of two pieces, after which we may observe the three articulated setæ prolonged beyond the body. The legs are rather short—the haunch often very large, much compressed, and squamiform. Several species occur in window-sashes which are seldom opened, beneath the planks of presses where there is any damp or moisture.

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[1] APTERA (pars) Linn.; SIPHONAPTERA, Lat.; APHANIPTERA, Kirby.

[2] See *Recherches sur les Caractères Zoologiques du genre Pulex*, par M. Ant. Dugès, in the *Annales des Sciences Nat.* Octobre, 1832; Curtis's *British Entomology*, pl. ccccxvii.; and Mr Westwood *On the Structure of the Antennæ in the Order Aphaniptera*, *Ent. Mag.* vol. i. p. 359.

A few seek the protection of stones. They run swiftly, and some leap well by means of their caudal appendages. The Linnæan genus is now divided into two.

In the genus Machilis, Lat. (*Petrobius*, Leach), Plate CCXXXIX, fig. 8, the eyes are extremely composite, almost contiguous, and occupy the larger portion of the head. The body is convex and arched above, and the abdomen is terminated by small setæ, adapted for leaping, and of which the central one, placed above the others, is much the longest. The maxillary palpi are very large, and pediform. The thorax is narrowed, with its first segment smaller than the others, and arched. These insects leap well and frequently. They dwell in stony and covered places. The species are few in number, and, as far as yet known, are European. We found the *P. maritimus* of Leach[1] in Fingal's Cave, in the island of Staffa.

In the genus Lepisma properly so called (*Forbicina*, Geoffroy, Leach), Plate CCXXXIX. fig. 7, the eyes are very small, distant, and less composite than in the preceding genus. The body is flattened, and the three terminal setæ are inserted on the same line, and are not adapted for leaping. The haunches are very large. The greater number are found in the interior of houses. They run swiftly, and when seized their silvery scales come off upon the fingers. The softness of the masticating organs in this genus would induce us to believe that they are incapable of gnawing hard materials. The most common species, *L. saccharina*, is said by Linnæus and Fabricius to feed on sugar and decayed wood,—and, according to the former, it likewise gnaws books and woollen garments. Geoffroy, however, is of opinion that it preys on the little *Psocus pulsatorius*, a small neuropterous insect, usually without wings, which we find both in houses and beneath the bark of trees. This Lepisma measures about four lines in length. It is of a silvery white, with a tinge of lead colour, and without spots. It is said to have come originally from America. Another species, which is represented by the figure last referred to, is distinguished by its ash-coloured body, spotted with black, and marked down the back by four black lines. Its localities are similar to those of the preceding species.

FAMILY II.—PODURELLÆ, Lat.

In this family, which corresponds to the genus *Podura* of Linn., the antennæ consist of only four articulations. The mouth does not exhibit distinct and projecting palpi. The terminal seta is forked, and when not in action is kept bent beneath the abdomen. These insects are extremely small, the body soft, elongated, with an oval head and two eyes, each formed of eight small granules. The legs exhibit only four distinct joints. The tail is soft, flexible, and composed of an inferior piece, moveable at the base, with two articulated appendages at the extremity, susceptible of being approximated, separated, or crossed. By striking this caudal process against the plane of their position, these insects possess the power of leaping into the air like fleas, although with less activity. They generally fall upon their backs, with their tails stretched out behind. Some are found on plants, beneath the bark of trees, or under stones; others on the surface of stagnant waters. They even occasionally occur, during time of thaw, in great quantities, on snow. When collected in numbers, they resemble a sprinkling of gunpowder.

These insects are oviparous, and undergo no transformations. They are completely formed on leaving the egg, although they speedily increase in size, and frequently change their skins. Degeer informs us that he observed them in Holland, alive and active, during the prevalence of a strong frost. The aquatic species do not long survive a removal from the water. They speedily shrivel up and die. But the terrestrial species support uninjured the heat of the mid-day sun even in dry and dusty regions. As far as we know, all the ascertained species are European, though we doubt not the genera exist in other quarters of the globe.

Parasita.

In Podura properly so called (Plate CCXXXIX. figs. 12 and 12 *a*), the antennæ are of nearly equal thickness throughout, and without annuli or small articulations at their extremity. The body is almost linear or cylindrical, with the thorax distinctly articulated, and the abdomen narrow and oblong.

In the genus Smynthurus, Lat. (*Podura*, Linn.), the antennæ become attenuated towards the extremity, and are terminated by an annulated portion, composed of small articulations. The thorax and abdomen seem united into a single globular or ovate mass. This genus corresponds to the second section of the *Poduræ* of Degeer. When touched, these insects make great leaps into the air by means of a setiform process at the end of the abdomen, resembling that of the preceding genus;—but they are moreover furnished with a very extraordinary organ, which we do not find in Podura proper. Beneath their body, and just between the points of the two forks of the tail, there exists an elevated cylindrical portion, from which issue two long membranous threads, transparent, extremely flexible, and glutinous or humid. They are rounded at the extremity, almost as long as the insect's body, and are thrown out with force and celerity, one on either side, from the cylindrical portion just mentioned, according to the insect's pleasure.

In regard to the uses of these peculiar parts of structure, Degeer observed that some Smynthuri which he had placed in an earthen vessel ejected their slimy organs whenever they found themselves, against their will, slipping down the sides of their prison. They then hung, as it were, suspended by these filaments, until they had time to take up a fresh position.[2] It may thus be reasonably inferred that their natural use or function is to prevent the insect's falling, when, after the execution of a powerful leap, it happens to alight upon a perpendicular or inclined surface. Degeer's observations apply to *Sm. fuscus*, Lat.,[3] a comparatively large species, synonymous with *Podura atra* of Linn.

Order XI.—PARASITA, Lat.[4]

The insects of this, our concluding order, are apterous, like those of the preceding; but their bodies are unprovided with articulated appendages, or other organs of locomotion, except the legs. Their organs of sight seem to consist solely of smooth or simple eyes (*yeux lisses*). Their mouth is in great part internal, and exhibits externally either a muzzle or projecting protuberance, enclosing a retractile sucker, or two membranaceous approximate lips, with a pair of hooked mandibles. These insects form in the Linnæan system the genus Pediculus, containing an extensive and varied group, known under the general and repulsive name of *lice*, and exhibiting in their structure and economy a great deal to interest the philosophical naturalist, notwithstanding the associations by which we unavoidably connect their existence with that of wretchedness and vice.

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[1] *Zoological Miscellany*, cxlv.

[2] *Mémoires*, t. vii. p. 35, pl. iii. figs. 7, 8.

[3] *Genera Crustac. et Insect.* t. i. p. 166.

[4] Aptera (pars) Linn.; Anoplura, Leach.

The unrestricted genus may be said to be generally characterized by a flattened body, almost transparent, and divided into eleven or twelve distinct segments, of which the anterior three bear the six legs. The first of these segments often assumes the form of a thorax. The stigmatic openings are very distinct. The antennæ are short, of uniform thickness, composed of five articulations, and frequently inserted in an emargination. On each side of the head there are one or two small simple eyes. The legs are rather short, and are terminated by a very strong claw, or by a couple of hooks directed one towards the other. These parasites, as many know by experience, attach themselves to man, beast, and feathered fowls. They likewise fix their eggs to hair and feathers; and as their generations are neither few nor far between, their superabundant increase under certain circumstances, not yet clearly understood, is sometimes such as to produce disease and death. The malady is called *phthiriasis*, from φθείρ, the Greek for louse.[1] Fabricius placed the Pediculi in his order *Antliata* (or Diptera), guided no doubt by a consideration of the parts of the mouth; while Dr Nitzsch, who has studied these insects with great attention, now ranks them with the Hemiptera, and at the same time classes the cognate genus Ricinus in the orthopterous order.

In the genus PEDICULUS properly so called (Plate CCXXXIX. fig. 11 and 11 *a*), the mouth is very small, mammillæform, and tubular, placed at the anterior extremity of the head, and, while not in action, enclosing a sucker. The tarsi consist of an articulation almost equal in size to the tibia, and terminated by a very strong claw, which, bending inwards upon a small projection, forms as it were a kind of nipper. Such of the species as Latreille has examined presented only a pair of simple eyes, one on each side.

Of the three species which infest the human race, *P. humanus corporis* is without spots. It infests the inner garments of beggars, and others who attach no importance to personal cleanliness, and is the cause of the disease above alluded to. The second species, *P. humanus capitis*, is more of an ash colour, with brown or blackish spots around the stigmatic openings, and the lobes of the abdomen are more salient. It occurs on the heads of children, and of dirty adults. In both these species the head and thorax are obviously distinct from the abdomen. In the third species, which forms the genus *Phthirus* of Dr Leach, the body is broad and rounded, the thorax very short and almost confounded with the abdomen, and the four posterior legs are very strong.

Of all these insects the powers of multiplication are great. Swammerdam viewed them as hermaphrodites, in as far as he could not satisfy himself regarding their distinctive sexual characters. But Leeuwenhoeck and Degeer, and recently Latreille and Doctors Nitzsch and Alibert, have shown that they do not differ essentially in these respects from other allied tribes. They are all oviparous, and their eggs are deposited on hair (see Plate CCXXXIX. fig. 11 *b*) or garments. The young are hatched in five or six days, and after several castings of their skin, or in about eighteen days, they become fit to reproduce their kind. In this way it has been calculated that a brace of females may prove the parents of *eighteen thousand young* in the space of two months. Oviedo remarked that the pediculi left the Spanish sailors at a certain latitude during their voyage to the Indies, and made their appearance again on the homeward progress about the same latitude. This we think was somewhere near the tropics; but the observation does not seem to have been confirmed by any special observations in more modern times. It is said, however, that in India they occur only on the head. These insects, however disgusting to people of refinement, are greedily sought after and *eaten* by those who may by some be regarded as belonging to the inferior orders, viz. Negroes, Hottentots, and Monkeys.

In the genus RICINUS of Lat. (Plate CCXXXIX. fig. 10), which corresponds to *Nirmus* of Hermann and Leach, the mouth is placed beneath, and consists exteriorly of two lips, and a pair of hooked maxillæ.[2] These insects, with the exception of a species found on dogs, are all bird-lice, that is, parasitical on the feathered creation. Their head, which, in common with the antennæ, occasionally differs in the sexes, is usually very large,—in some of a triangular form, in others semicircular or lunate,—and is frequently furnished with angular projections. Latreille has perceived a pair of simple eyes on each side of the head in several species. Besides the parts of the mouth just mentioned, Savigny satisfied himself of the presence of maxillæ, each bearing a very small palpus, and concealed by the labium or lower lip, which is also palpigerous. There is likewise a kind of tongue. The Ricini are much less sluggish in their movements than the Pediculi properly so called. They glide about among the feathers of birds with considerable agility, and are captured with difficulty, by reason of the flatness of their forms and adhesive propensities. When a bird dies, however, they assemble together about the base of the beak, and other parts of the head, and moving about with an air of inquietude, they seem to watch for an opportunity of making their escape to some living prey. M. Leclerc de Laval detected portions of the plumage in their stomachs, and he is of opinion that these constitute their sole subsistence; but Degeer found the Ricinus of the chaffinch gorged with blood; and their extreme anxiety to change their quarters the moment that circulation ceases, argues a fancy for something more than feathers.

We have at last brought to a conclusion an article which the reader may possibly regard as of inordinate length, but which the writer has certainly found far too narrow for the proper elucidation of several departments of his subject. "And here it is not out of place to remark, that it is the very perfection of the divine workmanship which leads every inquirer to imagine a surpassing worth, and grace, and dignity, in his own special department of it. The fact is altogether notorious, that in order to attain a high sense of the importance of any science, and of the worth and beauty of the objects which it embraces, nothing more is necessary than the intent and persevering study of them. Whatever the walk of philosophy may be on which man shall enter, that is the walk which of all others he conceives to be most enriched by all that is fitted to entertain the intellect or arrest the admiration of the enamoured scholar. The astronomer who can unravel the mechanism of the heavens, or the chemist who can trace the atomic processes of matter upon earth, or the metaphysician who can assign the laws of human thought, or the grammarian who can discriminate the niceties of language, or the naturalist who can classify the flowers, and the birds, and the shells, and the minerals, and the insects which so teem and multiply in this world of wonders,—each of these respective inquirers is apt to become the worshipper of his own theme, and to look with a sort of indifference, bordering on contempt, towards what he imagines the far less interesting track of his fellow-labourers. Now each is right in the admiration he renders to the grace and grandeur of that field which himself has explored; but all are wrong in the distaste they feel, or rather in the disregard they cast on the other fields which they have never entered. We should take the testimony of each to the worth of that which he does know, and reject the testimony of each to the comparative worthlessness of that which he does not know; and then the unavoidable inference is, that that must be indeed a replete and a gorgeous universe in which we dwell,—and still more glorious the Eternal Mind, from whose conception it arose, and whose prolific fiat gave birth to it in all its vastness and variety."[1] (T.)

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[1] It is well described by M. Alibert, in his treatise *Sur les Maladies de la Peau.*

[2] The genus Ricinus was established by Degeer, who first recognised that these insects were distinguished from Pediculi by the existence of mandibles. The name was applied by the ancients to certain acarideous species of the genus now called *Ixodes*, and for that reason has not been adopted by some modern naturalists, who prefer the name of *Nirmus*.

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[1] Chalmers' Bridgewater Treatise *On the Adaptation of External Nature to the Moral and Intellectual Constitution of Man*, vol. ii. p. 173.

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ENTRE DUERO E MINHO, one of the provinces into which the kingdom of Portugal is divided. As its name denotes, it is bounded on the north by the river Minho, which divides it from Spain, and on the south by the river Duero. The Atlantic Ocean is its western boundary, and on the east a chain of elevated mountains separates it from the province of Tras os Montes. It has by far the most dense population of any part either of Spain or Portugal, and extends over a surface of 291 square leagues. The number of its inhabitants in 1798 amounted to 907,965.

It enjoys the best climate, the most fertile soil, and the most beautiful rivulets, not only of Portugal, but of the whole peninsula. Its vegetable productions are oranges, lemons, maize, wheat, and especially wine. The latter article is the great object of export, and forms the principal trade of the kingdom, as almost all the red wine, commonly named port, from the city whence it is shipped, is the growth of Entre Duero e Minho. Both its sea coasts and rivers abound with most excellent fish, which forms the foundation of considerable commerce. Considerable manufactures are conducted, which furnish hats, linens, sail-cloth, woollen cloths, and various kinds of silks and satins. These, though not sufficiently cheap to be sent to other parts of Europe, supply the demands of the kingdom, and a portion is exported to Brazil and the settlements on the coast of Africa. The rivers next in importance to those which bound it are the Lima, the Cabado, the Deste, and the Ave, all which run from east to west, and form natural defences, aided by the mountains, against any invading enemy. The city of Braga is the capital, though Oporto is in every respect the first city in the province, only that Braga, as the see of an archbishop, is usually considered as the chief place. This province lies between 41. 6. and 42. 6. north latitude.

ENTREPAS, in the manège, a broken pace, which is neither walk nor trot, but is somewhat of an amble.

ENTRY, in *Law*, signifies taking possession of lands or tenements, where a person has a right so to do.

ENTRY *of an Heir*, in *Scotch Law*, that legal form by which an heir vests in himself a title to his predecessor's estate.

ENUMERATION, an account of several things, in which mention is made of every particular article.

ENUMERATION, in *Rhetoric*, a part of the peroration, in which the orator, collecting the scattered heads of what had been delivered throughout the discourse, makes a brief and artful relation or recapitulation of the whole.

ENVELOPE, in *Fortification*, a work of earth, sometimes in the form of a simple parapet, and at others like a small rampart with a parapet. It is sometimes raised on the ditch, and sometimes beyond it. Envelopes are of a zigzag form, in order to enclose a weak ground, with single lines, where that is practicable, or to save the expense of horn-works, crown-works, and tenailles, where room is wanting for such defences. Envelopes in a ditch are called sillons, counter-guards, and lunettes.

ENVIRONNE', in *Heraldry*, signifies surrounded with other things. Thus, they say, a lion environné with so many bezants.

ENVOY, a person deputed to negotiate some affair, not of a very solemn or important nature, with any foreign prince or state.

ENVY, pain felt, and malignity conceived, at the sight of excellence or happiness in another.

ENZELLI, a town of Persia, in the province of Ghilan, built entirely of reeds, as the sandy soil will not bear a more solid edifice, and consists of two parts, New and Old, inhabited by Persians, Armenians, and Russians. It is six miles north of Reshd.

EONIANS, in *Ecclesiastical History*, the followers of Eon, a wild fanatic of the province of Bretagne, in the tenth century. He concluded, from the resemblance between *eum*, in the form of exorcising malignant spirits (*per eum, qui venturus est judicare vivos et mortuos*), and his own name Eon, that he was the son of God, and ordained to judge the quick and dead. Eon, however, was solemnly condemned by the council at Rheims in 1148, at which Pope Eugenius III. presided, and he ended his days miserably in a prison. This insane fanatic left behind him a number of followers and adherents, whom persecution and death could not persuade to abandon his cause, or to renounce an absurdity which, as Mosheim observes, one would think could never have gained credit in any place but bedlam.

EOOA, EAOOWE, or MIDDLEBURG. This island is the most eastern of the Friendly Islands, in the South Pacific Ocean. It is about thirty miles in circuit, and has an elevated and unequal surface. The north-east coast rises suddenly, but the north-west consists of valleys, meadows, and plains, abounding with groves of fruit trees, sugar-canes, bananas, shaddocks, and vegetables of various sorts. It was discovered in 1643, by Tasman, who called it Middleburg. Long. 174. 30. E. Lat. 21. 24. S.

EORIA, in *Mythology*, a feast celebrated by the Athenians in honour of Erigonus, who, by way of punishment for their not avenging the death of his father Icarus, induced the gods to inflict on their daughters the curse of loving men who returned not their passion. The feast was instituted by the order of Apollo.

EOSTRE, in *Mythology*, a Saxon goddess to whom sacrifices were offered in the month of April, called the month of *Eostra*; and hence the name *Easter*, which the Saxons retained after their conversion to Christianity, applying it to the festival celebrated in commemoration of our Saviour's resurrection.

EPACTS, in *Chronology*, the excess of the solar month above the lunar synodical month, and of the solar year above the lunar year of twelve synodical months; or of several solar months above as many synodical months, and several solar years above as many dozen synodical months. See CHRONOLOGY.

EPAMINONDAS, son of Polymnis the Theban, born about 410 B.C., was one of those distinguished characters whose appearance forms an epoch in the history of their country. The position of Thebes was not such as to enable it to take a prominent part in the affairs of Greece; and, excepting during the short period when Epaminondas and Pelopides were at the head of the government, it seems to have been dependent either on Sparta or on Athens, according as the power of the one or the other prevailed. The earlier years of Epaminondas were spent under the direction of Lysis the Pythagorean philosopher; and, if we may credit the story told by Diodorus, he was the fellow-student of Philip of Macedonia. Devoted though he seems to have been to the study of philosophy, he did not neglect those lighter accomplishments which add grace to the character; and Nepos even thinks it necessary to tell us the names of the masters from whom he derived his knowledge of music and dancing.

At the period when Epaminondas appeared upon the stage, the small republics of Greece were torn to pieces by intestine dissensions; at one time the party of the rich and noble prevailed, at another the power of the democracy was predominant. Of the latter party Athens was the main prop, whilst Sparta was the powerful friend of the former. It does not appear that Epaminondas in his earlier years took any prominent part in support of either faction, being probably disgusted by the intrigues and remorseless cruelty which he saw practised by all parties in the pursuit of whatever object they had in view. He was present indeed at the battle of Mantinea (385 B. C.), fought between the Arcadians and Spartans; and it was mainly through his efforts that it was decided in favour of the latter, on the very same ground which was destined a few years afterwards (362 B. C.) to witness his own death, and the defeat of his allies.

During the whole period of his political life his friendship with Pelopidas was uninterrupted, and, according to Plutarch, nothing reflected greater glory on both, than that they never allowed a feeling of rivalry to interfere with their exertions for their common country. Yet no two individuals could possibly be more dissimilar in character, as Pelopidas loved all the pomp and splendour of power, whilst Epaminondas was better pleased to remain in poverty and retirement. The nobles, mistrusting their own strength, received a Spartan garrison (382 B. C.) into their citadel, and Pelopidas and the chiefs of the popular party were banished; but Epaminondas, who was supposed to be more engaged in the speculations of philosophy than in the active affairs of life, was allowed to remain. Three years afterwards a conspiracy was formed to recover the independence of Thebes; but though his friend Pelopidas was at its head, Epaminondas refused to join in the attempt, wisely judging that the bloodshed and rapine which would inevitably follow any violent change in the government must more than counterbalance the good anticipated from the success of the popular party. The conspirators succeeded without his assistance, yet prudently adopted the moderate counsels which he recommended. The Spartans made an attempt to recover their power, but, being defeated by Pelopidas, were induced to listen to terms of accommodation. A general diet of all the states of Greece was summoned at Sparta, in order that peace might be established on just and sound principles. Epaminondas was the deputy appointed by Thebes, and the able manner in which he maintained the interests of his country did not disappoint the expectations of his fellow-citizens. He refused to emancipate the cities of Bœotia from the control of Thebes, unless Sparta was prepared to act the same part towards those subject to her in Laconia. Negotiations were broken off, as neither party showed a disposition to yield, and orders were sent to Cleombrotus the Spartan general, then in Phocis, to commence hostilities against the Thebans. It was now that Epaminondas, by the consent of all, was appointed to the chief command, and the measures which he took to protect the country from the incursions of Cleombrotus were so complete that they compelled the Spartan general to retire from Chæronea, where he had taken up his position. Cleombrotus descended from the mountains to the sea shore, and passing along the difficult and rugged coast at the foot of Mount Helicon, reached without interruption the plains of Leuctra, at no great distance from Thebes. Here he found the troops of the Thebans posted on the heights around; and in the council of war which was held it required all the ability of Epaminondas to persuade the officers that the fate of their country ought to be staked on the chances of a general engagement. In this, however, he succeeded, and immediately drew out his men in order of battle.

The result of his arrangements was a complete victory, gained in July 371 B. C. To his friends who congratulated him he answered, "that his chief pleasure arose from his parents being alive to enjoy his triumph." Two years after this battle he entered the Peloponnesus at the head of 70,000 men, carrying terror and desolation to the very gates of Lacedæmon, which had not for five or six centuries seen the smoke of an enemy's camp. He was compelled, however, to retire, by the able generalship of Agesilaus, though not until he had devastated the whole country around. On his return home he was brought to trial, along with Pelopidas and the other generals, for having retained his command four months beyond the time specified by law. He recommended the other generals to plead as their excuse his superior orders, and then boldly said to the assembly, "I acknowledge that the law condemns me to death; all I ask is, that the sentence passed on me may be couched in these words: Epaminondas was punished for having conquered the Spartans at Leuctra, for having besieged Lacedæmon, and rebuilt Messene." The boldness of this answer was of course applauded, and Epaminondas acquitted; yet his enemies had sufficient influence with the people to exclude him from all honourable employment. Some time afterwards he redeemed his character by a successful campaign against Alexander, the tyrant of Pheræ, in Thessaly, and by delivering his friend Pelopidas from the hands of that unprincipled despot. A war broke out between the Tegeates in Arcadia, who had implored the assistance of the Thebans, and the Mantineans, who were supported by Lacedemon. The two armies met near Mantinea, the modern village of *Paleopoli*, when Epaminondas employing a manœuvre similar to that which had succeeded at Leuctra, gained a complete victory, but was wounded by a javelin, the iron point of which remained in his body. Before he expired, he inquired for the generals Deiphantus and Jollidas, and being told they were dead, he added, "Then persuade the Thebans to make peace." In fact, from this moment, Thebes, to use the expression of an ancient writer, was a javelin deprived of its iron point, and ceased to be formidable. Epaminondas died on the 4th July 362 B. C. one of the most perfect models that Greece presents of a great captain, a true patriot, and a philosophic sage.

His life was written by Plutarch, but it has been unfortunately lost; there are, however, many details of it contained in the lives of Agesilaus and Pelopidas, and also in his moral works. But it is to Xenophon that we are indebted for the chief facts. The life of Epaminondas by Cornelius Nepos has been evidently mutilated. The reader may also consult Diodorus Siculus, x. xvi. xv.; Pausanias, Polybius, Ælian, and Valerius Maximus. A long and uninteresting life has been published by De la Tour, Paris 1739, 12mo; by Meismer, in German, 12mo, Prague, 1798; and in the *Mémoires de l'Acad. des Inscript. et Belles Lettres*, vol. xiv. p. 113.

EPARER, in the manège, signifies the flinging of a horse, or his yerking and striking with his hind legs.

EPAULEMENT, in *Fortification*, is a kind of breastwork, constructed to cover the troops in front, and sometimes also in flank. In a siege, an epaulement of eight or ten feet in height is generally raised near the entrance of the approaches, in order to cover the cavalry which is placed there to support the guard of the trenches. These works are commonly constructed of filled gabions, or of fascines and earth intermixed. The term epaulement is frequently applied to any work thrown up to defend the flank of a post or other place; it also denotes sometimes a demi-bastion, and at others a square orillon, for covering the cannon of a casemate.

EPAULETTES are a kind of military shoulder-knots, which are made of different materials, according as they are worn by officers or by common soldiers.

EPENTHESIS, in *Grammar*, the interposition or insertion of a letter or syllable in the middle of a word; as *alituum* for *alitum*, *relligio* for *religio*, *induperator* for *imperator*, and the like.

EPERIES, a city of Hungary, in the circle of the Hither Theiss. It is the seat of the several boards for the government of the circle, and contains 806 houses, and 7426 inhabitants, who make much linen and woollen goods, and some very excellent wine. Long. 21. 10. 25. E. Lat. 48. 58. 45. N.

EPHA, or EPHAH, in Jewish antiquity, a dry measure, equal to three pecks and three pints.

EPHEBÆUM, in *Antiquity*, the place where the ephebi or youth exercised; or, as some think, where those who designed to exercise met and agreed on the kind of exercise which they should contend in, and what should be the victor's reward.

EPHEBI, among the Athenians, a designation given to their young men when they arrived at eighteen years of age, at which period they had their names entered in a public register.

EPHEMERA, from ἡμερα, *a day;* a diary fever, or a fever of one day's continuance.

EPHEMERIDES, in *Astronomy*, tables calculated by astronomers, showing the actual state of the heavens for every day at noon; that is, the places in which all the planets are found at that time. It is from these tables that the eclipses, conjunctions, and aspects of the planets are determined. In England, the *Nautical Almanack, or Astronomical Ephemeris*, published annually by anticipation, under the direction of the Board of Longitude, is the most considerable work of the kind.

EPHESUS, the chief city of Ionia, in Asia Minor, on the south side, and near the mouth of the river Cayster (now called Kutchuc Mendere, or Lesser Mæander), was 320 stadia, or forty miles, to the south of Smyrna, and 540, or three days' journey, from Sardis, the capital of Lydia. It was situated at the extremity of a rich and beautiful plain, called Campus Cilbianus, through which the river flowed, and which still retains its former character, after centuries of Turkish oppression. Ephesus was originally founded by the Leleges and Carians, who were compelled to make way for an Ionian colony led by Androclus, son of Codrus. The inhabitants continued to be distributed over the neighbouring district until the reign of Crœsus (560 to 546 B.C.), when, being attacked by that prince, they are said to have dedicated their city to Diana, by fastening a rope from their walls to the temple of the goddess. They gradually deserted the ancient site, and approached the position of the sacred temple, where they are said to have continued until the time of Alexander the Great (330 B. C.). Lysimachus having obtained possession of the city (302 B. C.), compelled the inhabitants, by inundating the ancient site, to remove higher up to a spot which he surrounded with walls. We find that it was delivered over to the kings of Pergamus by the Romans, after the defeat of Antiochus (190 B. C.); and, amidst all the changes of government which subsequently took place, Ephesus continued to increase in riches and prosperity, being in the time of Strabo (24 B. C.) the emporium of Asia. It was considered by the Romans as the first of the three chief cities of Asia, the two others being Smyrna and Pergamus; and in the later divisions of the country under the Christian emperors, we are told by Hierocles that it was the capital of the important provinces of Asia. Ephesus was lost to the empire at an earlier period than the other parts of Western Asia. Some time before the commencement of the Crusades (1096 A. D.), a chief of the Saracens made himself master of Ephesus; but the crusaders restored it to its ancient master. In the fourteenth century it fell into the hands of a prince of Caramania named Sasan; and from this time it ceased to belong to the Greek empire. It still, however, continued to exist down even to the time of Timur or Tamerlane (1370 A. D.), who for a considerable period had a camp under its walls, and who is supposed to have destroyed it, as he did many other cities.

Ephesus was more particularly celebrated on account of the temple of Diana, which, according to Pausanias, existed even before the arrival of the Ionians. Its architect was Chersiphron of Cnossus, in Crete, assisted by his son Metagenes; and as the ground on which the temple was erected was marshy, it is said that he obtained a firm foundation by means of heaps of charcoal and wool, packed closely together in sacks. It was the only temple in Asia which escaped the doom pronounced against them by Xerxes on his return from Greece (480 B. C.); but it was burnt to the ground 356 B. C. by a madman named Eratostratus, who is said to have taken this method of immortalizing his name. This event took place the very night on which Alexander the Great was born; and the temple seems to have remained in ruins till that monarch offered to restore it, on condition that he should be declared the founder. This proposal, however, the Ephesians declined to accept, cunningly soothing the wounded vanity of the hero by saying, "that it was beneath the dignity of one god to erect a temple to another." Having collected sufficient funds amongst themselves and their neighbours, they entrusted its restoration to the architect Dinocrates, who is reported to have conceived the extravagant project of forming a statue of Alexander out of Mount Athos. The new edifice was much larger, and constructed with more magnificence, than the original temple. It was 425 feet in length and 220 in breadth, with 227 pillars, each 60 feet in height. It is said to have been of the Ionic order of architecture. The interior was adorned with numerous pieces of sculpture by the celebrated Praxiteles. Thraso and Scopas were also employed in its decoration; and there was a picture in it by the celebrated Apelles. The statue of the goddess was more particularly the object of veneration, having been preserved in safety amidst all the vicissitudes to which the temple and city had been exposed. It was of wood, and, according to Pliny, was covered with some unctuous substance, to guard it from decay. The service of the temple was performed by priests called Megabyzæ, who were eunuchs, and to whom were added a number of priestesses. The temple was an asylum for criminals of every description. Alexander extended the privilege to a stadium round the edifice; Mithridates fixed it at a bow-shot; and Antony doubled the distance, so that it included part of the town. It may easily be conceived that such a privilege must have been liable to great abuses; and in fact it became at last so dangerous to the peace of the city, that Augustus caused it to be abolished. It was seven stadia, or about an English mile, from the walls of the city; but no modern traveller seems yet to have discovered its remains. Pococke has indeed given a ground plan of what he considered as the temple; but his description by no means agrees with what is related of the seventh wonder of the world.

The ruins of Ephesus are seen half a mile from the Turkish village of *Aiasluk*, which seems to have risen about the middle of the fourteenth century. Chandler thus speaks of its present appearance: "Ephesus was situated by the mountains which are the southern boundary of the plain, and comprehended within its walls a portion of Mount Prion and of Corissus. Mount Prion is a circular hill; Corissus a single lofty ridge, extending northward from near Mount Pactyas, and approaching Prion, then making an elbow, and running westerly towards the sea. We entered Ephesus from *Aiasluk*, with Mount Prion, and the exterior lateral wall of a stadium which fronted the sea, on our left hand. We measured the area, and found it 687 feet long. The vestiges of the theatre alluded to in the Acts of the Apostles, which was very capacious, are farther on in the side of hetæ || hori

Ephorus.

the same mountain. Going on from the theatre, you come to a narrow valley which divides Mount Prion from Corissus. Within the valley you find broken columns and pieces of marble, with vestiges of an odeum in the slope of Prion. Beyond the odeum the valley opens gradually into the plain of *Aiasluk*. Keeping round by Prion, you meet with vestiges of buildings, and come to the remains of a large edifice. This was the gymnasium. The street at the entrance of the city from *Aiasluk* was nearly of the length of the stadium. The opposite side was composed of edifices equally ample and noble. The way was between a double colonnade, as we conjectured, from the many pedestals and bases of columns scattered there. This street was covered by one leading from the plain to the valley. It had on the left the front of the stadium, and the theatre with the portico adjoining. On the right are ample substructures, with pieces of massive wall. These remains reach as far as the portico, and have behind them a morass, once the city port. The extent of the city towards the plain, on which side it was washed by the Cayster, cannot now be ascertained; but the mountainous region has preserved its boundary, the wall erected by Lysimachus, which is of excellent masonry. Near the entrance of Ephesus from *Aiasluk* are the vaults of several sepulchres, and others along the slope of Corissus show that the Ephesians buried likewise within the city." (*Travels in Asia Minor*, chap. 35.)

EPHETÆ, judges who in early times presided over he five criminal courts of justice at Athens, taking cognizance of every description of homicide. They were ifty-one in number, and required to be of noble birth. Solon first separated the Areopagus from the other four courts; and from this time the jurisdiction of the ephetæ vas confined to cases of unintentional or justifiable homiide. It formed part of their duty to see that the person vho had committed the act should be properly expiated y sacrifice and other rites. He was obliged to leave his ountry, by a particular road, for a certain time, which vas generally eight years, though at Athens it was proably undetermined. During this time he was bound to eep at a distance from places of public resort; and when e returned, a reconciliation took place, either with the indred, or certain chosen ploratores. (See Plutarch, *Solon*, 29; Pollux, viii. 125.)

EPHOD, in Jewish antiquity, a part of the priestly abit, being a kind of girdle, which, being brought from ehind the neck over the two shoulders, and hanging own before, was put across the stomach, then carried ound the waist, and made use of as a cincture to the unic. There were two sorts of ephods; one of plain linen or the priests, and the other embroidered for the high riest.

EPHORI, ancient Doric magistrates, whose power and nfluence seem to have varied at different times. In Sparta the college consisted of five, and they entered on their nnual office at the autumnal solstice, the beginning of e Lacedæmonian year. The first of these magistrates ave name to the year, in the same way as the first elected consul did at Rome; and they began their official dues by publishing a species of edicts, in which they appointed the secret officers or κρυπτοι. In this edict was ound the strange metaphorical expression for subjection nd obedience, "that they must shave the beard and obey e laws." They held their daily meetings in an office et apart for them (ἀρχειον), where they were also in the abit of eating together.

It is supposed by Müller, in his able treatise on the political institutions of the Dorians, that the duties of the phori were originally limited to the superintendence of ales, and of the public markets. Aristotle informs us, whilst describing their judicial powers, that they decided civil causes, but that the council presided over all capital crimes. It appears therefore that the court of ephori gave judgment respecting civil duties and property. The Periæci and Helots, when they were in Sparta, were also under its jurisdiction. But the ephori gradually extended their authority; and it seems to have been the usual course of events in Greece, that the civil courts should enlarge their influence, whilst the power of the criminal courts was continually on the decline.

The circumstance which seems principally to have extended the jurisdiction of the ephori, was the privilege they enjoyed of instituting an inquiry into the official conduct of all magistrates, excepting that of councillors. We do not mean to say that this scrutiny always took place; but the ephori had it in their power to compel any magistrate to stand his trial, if they had remarked any thing suspicious in his administration. The king was not exempted from this power, but bound to yield as implicit obedience as the lowest officer of the state. Thus we find Cleomenes tried for bribery before the Persian war. But it must not be supposed that the ephori could of themselves punish with death: they were only the accusers before a larger court, which consisted of all the councillors, of the ephori themselves, who seem to have acted both as accusers and judges, of the other king, and probably of several other magistrates, who had all equal votes. The ephori had only the power to impose fines, and to demand immediate payment. Thus Agesilaus was fined for endeavouring to make himself popular; whilst Archidamus was reprimanded for having married a wife of too small stature. Sometimes we find them punishing one man for having introduced money into the state, another for indolence, and a third for the most extraordinary reason, namely, that he was generally ill treated and insulted.

The ephori appear from very ancient times to have had a right to transact business with the popular assembly in preference to any other magistrates. They could convene the people and put the vote to them. They had great authority in transacting with foreign nations, admitting ambassadors, and dismissing them from the confines of the kingdom. In time of war they were empowered to send troops on whatever day they thought fit, and seem even to have been able to determine the number of men. The army was then entrusted to the king, or some other general, who received from them instructions how to act, and was even restrained in his proceedings by deputies whom the ephori sent to watch over him. The general could be recalled by the scytala, and their first duty was to visit the office of the ephori. It is impossible, however, to believe that the ephori could act by their own authority on such important occasions as these; they could only have been the agents and plenipotentiaries of the popular assembly. It must in fact have been the decrees of the people which they put in execution.

The office of the ephori was abolished by Cleomenes, but restored under the Roman dominion. (See Müller's *Dorier*, Breslau, 1824, t. ii. p. 111–129.)

EPHORUS, a celebrated Greek historian of Cunæ in Æolis, born about the year 362 B. C., a year memorable for the battle of Mantinea. His father's name was Demophilus, or Antiochus; and being contemporary of Eudoxus and Theopompus, he studied along with them under the philosopher Isocrates. Of his personal history we are entirely ignorant; and if it were not for the high character he enjoyed among the ancients as an orator and historian, his name would be unworthy of notice. It was Isocrates who directed his attention more particularly to that branch of literature in which he eventually became so eminent; and, to mark the distinctive peculiarities in the mind and character of his two pupils Theopompus and Ephorus, the philosopher is reported to have said, " se calcaribus in Ephoro, contra autem in Theopompo frenis uti solere."

The great work of Ephorus was a history of the wars between the Greeks and Persians, in which, like Herodotus, he introduced, in the form of episodes, the description of foreign and barbarous nations, yet only in as far as they were connected with and served to illustrate Grecian history. It must be allowed, however, that the Greeks considered the work of Ephorus as an universal history; but then this may be explained from the extreme vanity of that nation, in believing that their history was the central point on which that of the whole world turned. Meier Marx, who has published a collection of the fragments of this work, has endeavoured to give us the contents of the thirty books of which it was composed.

The first book contained an account of the return of the Heraclidæ into the Peloponnesus, and the change of affairs consequent upon that event; and the second was occupied with the state of the rest of Greece; and the third narrated the departure of the Greek colonies to Asia. In these three books he thus brought the history of Greece and Asia down to that period when they began to assume a peaceful aspect, probably a few years before the commencement of the Median war. After this introduction he proceeded to describe separately each country which subsequently became the scene of important transactions; in the fourth book Europe, in the fifth Asia and Africa, and in the sixth he probably gave an account of the nation of the Pelasgi. The seventh book contained the most ancient traditionary notices of Sicily, and probably all he could collect respecting the original inhabitants of Italy and the adjacent islands. The eighth book narrated the various changes of fortune to which those nations had been subject, who in succession held the supreme command in Asia, namely, the Assyrians, Lydians, and Persians. The fragments which remain refer principally to the affairs of Crœsus. In the ninth book we had the origin, changes, and migrations of the Amazons, Scythians, and other nations who inhabited the coasts of the Pontus and those northern countries, whence, through Thrace and Thessaly, he returned to Greece and its affairs. Then it was that Ephorus reached the period when, like every Greek historian, he imagined that the transactions of the whole world became centred in the causes and events of the Persian war; and then also he began to treat his subject with more copiousness, for we find that in his tenth book he had already brought down his history to the times of Miltiades, about 490 B. C. In his eighteenth book he had reached Dercyllidas, 399 B. C. In his twenty-fifth he had arrived at the battle of Mantinea, 362 B. C. We thus see that he must have employed seven or eight books in describing thirty-seven years, whilst his last four or five books could contain the history of only twenty-two years. The part of the thirtieth book which gave an account of the sacred war was composed, not by Ephorus himself, but by his son Demophilus; at the conclusion of the war Ephorus took up the thread of the history, and continued it to the siege of Perinthus, 340 B. C. According to Diodorus Siculus, the whole period treated of was 750 years.

For a more full description of the life of Ephorus, and a collection of the fragments of his history which have been preserved, the reader may consult *Ephori Fragmenta a Marxio*, Caroluh, 1815; Creuzer, *Symbolik und Mythologie der alten Volker, besonders der Griechen*, Leipsic, 1819; Vossius *De Historicis Græcis*, Lugd. Bat. 1651; and Ulrici, *Charakteristik der antiken historiographie*, Berlin, 1833.

EPHRAIM, in *Ancient Geography*, one of the tribe divisions of Palestine. Ephraim and the half tribe of Manasseh are blended together by the sacred writer; and it appears that Ephraim occupied the more southern, and the half tribe of Manasseh the more northern parts, but both seem to have extended from the Jordan to the sea. Ephraim also denotes a kingdom, on the separation of the ten tribes from the house of David, called the kingdom of Israel and Samaria.

EPHREM SYRUS, an ancient Christian writer, in the fourth century, deacon of Edessa, was born at Nisibe in Syria. He was greatly esteemed by Basil, Gregory Nazianzen, and other eminent men. He wrote against the opinions of Sabellius, Arius, Apollonarius, and the Manichæans, and acquired such reputation that he was styled the doctor and the prophet of the Syrians. He died in the year 378. The best editions of his works are, that of Oxford, in 1708, in folio; and that of Rome, from 1732 to 1738, in Syriac, Greek, and Latin, six vols. folio.

EPHYDOR, in *Antiquity*, an officer in the Athenian courts of justice, whose business it was to provide the plaintiff and defendant with equal water hour-glasses. When the glass had run out, they were not permitted to speak any longer; and therefore we find them very careful not to lose or mis-spend one drop of the water. Whilst the laws quoted by them were reciting, or if any other business happened to intervene, they gave orders that the glass should be stopped.

EPIBATÆ, part of the crew which manned an Athenian vessel. The triremes of this people were of two sorts, either swift-sailing vessels or transport ships. The latter were filled with land forces which it was intended to transport to some particular point, and, being heavily laden, were never employed in battle excepting in cases of great emergency; the former contained only the necessary crew for the working and defence of the vessel. The troops embarked in these transports were, like all other passengers by sea, called Epibatæ. But the crew also of the swift-sailing vessels consisted of two distinct bodies of men; the soldiers intended for their defence, called Epibatæ, who seem to have occupied the place of our marines; and the sailors who were employed for the purpose of working the vessel. These Epibatæ were perfectly distinct from the land forces, the oplitæ and pellestæ, and were entirely devoted to the sea. It seems difficult to decide how many of them were attached to each ship, for there are only two passages in ancient authors from which any inference can be drawn. Herodotus (vi. 15) says, that the Chians, when they armed one hundred ships against the Persians, embarked forty able-bodied citizens as Epibatæ in each trireme; whilst Plutarch (in *Themist.* 14) tells us that there were only eighteen Epibatæ on board the Attic triremes at Salamis, four of whom were archers, and the rest heavy-armed men. See Böckh, *Die Staatshaushaltung der Athener*, vol. i. p. 301, Berlin, 1817.

EPIBATERION, a poetical composition, in use amongst the ancient Greeks. When any person of condition and quality returned home after a long absence or journey into another country, he called together his friends and fellow-citizens, and made them a speech, or rehearsed a prepared copy of verses, in which he returned solemn thanks to the immortal gods for his happy return, and ended with an address by way of compliment to his fellow-citizens. These verses formed what the Greeks call επιϐατεριον, *epibaterium*, from επιϐαινω, *I set out.* On the occasion of departure they had another analogous composition, called *apobaterium*.

EPIC, or HEROIC, *Poem*, a poem expressed in narration, formed upon a story partly real and partly feigned, and representing, in a sublime style, some signal and fortunate action, distinguished by a variety of great events, in order to form the morals, and affect the mind with the love of heroic virtue. See Poetry.

EPICEDION (from επι, *upon*, and κηδος, *funeral*), in Greek and Latin poetry, a poem, or poetical composition, on the death of any one. At the obsequies of persons of consequence there were three kinds of discourses usually made; that rehearsed at the *bustum* or funeral pile was called *nenia;* that engraven on the tomb, *epitaphion;* and that spoken in the ceremony of his funeral, *epicedion.* We have two beautiful epicedions in Virgil; that of Euryalus, and that of Pallas.

EPICEDIUM, in ancient poetry, a poem rehearsed during the funeral ceremonies of persons of distinction.

EPICHARMUS, a celebrated poet of the old comedy, the son of Helothales, a native of Cos, but who having been carried into Sicily at the age of three months, is generally known as a Sicilian, the name of his adopted country having prevailed over that of the country of his birth. He was a pupil of Pythagoras; for there seems abundant proof that Epicharmus the Pythagorean and Epicharmus the father of the old comedy were one and the same person. He was the author of many comedies, written in trochaic tetrameters, which he began to exhibit about the year 500 B. C., and continued down to the reign of Hiero, 477 B. C. Plautus is said to have imitated him (Hor. *Ep.* ii. 1, 57), and Ennius translated one of his moral works. He used to say that the principal requisite in a philosopher was not to believe rashly. (Cic. *De Petit. Cons.* c. 10.)

Epicharmus is much less known and esteemed than his peculiar style of writing and dramatic skill deserve. The subjects of his plays were mostly mythological, being parodies or travesties of mythology, nearly in the style of the satirical drama of Athens. Thus, in the comedy of Busiris, Hercules was represented in a most ludicrous light as a voracious glutton; and he seems again to have been exhibited in the same character in the Marriage of Hebe. It is supposed that the figures on a vase now preserved in the British Museum, and which was found at Bari in the kingdom of Naples, were intended to represent the characters in the play of Epicharmus entitled Vulcan, or the Revellers. (See Millin, *Galerie Mythologique,* xiii. 48, for the figures.) The play began, as we are told, with Vulcan chaining his mother Juno by magical charms to a seat, from which he only released her after long entreaties. Vulcan being, in consequence of this act, ill treated by his parents, entirely deserted Olympus, until Bacchus, having made him drunk, placed him on an ass, and thus brought him in jolly merriment back to Olympus. But Epicharmus, like Aristophanes, sometimes handled political subjects. Thus, according to Hemsterhuis (*ad Pollux,* ix. 4. 26), the piece called Ἁρπαγις, or the Plunderings, which described the devastation of Sicily in his time, had a political meaning; and this was perhaps also the case with "The Islands." The style of his plays was not less various than his subjects; he passed from rude buffoonery to a more serious strain, introducing maxims and moral sentences, together with precepts of the Pythagorean philosophy. That the dramatic style of Epicharmus was perfect in its kind is proved by the great admiration in which it was held by the ancients, particularly by Plato.

EPICHIROTONIA, amongst the Athenians. It was ordained by Solon, that once every year the laws should be carefully revised and examined; and that if any of them were found unsuitable to the actual state of affairs, they should be repealed. This was called επιχειροτονια των νομων, from the manner of giving their suffrages by holding up their hands. (See a further account of this custom in Potter, *Archæol. Græc.* tom. i. p. 242.)

EPICŒNE, in *Grammar,* a term applied to nouns, which, under the same gender and termination, mark indifferently the male and female species. Such in Latin are *aquila, vespertilio,* and the like, which signify equally a male or female eagle or bat.

Grammarians distinguish between *epicœne* and *common.* A noun is said to be common of two kinds, when it may be joined either with a masculine or a feminine article; and epicœne, when it is always joined to some of the two articles, and yet signifies both genders.

EPICTETUS, a native of Hierapolis, in Phrygia, was born of humble parents, in the first century of the Christian era. In his youth he was the slave of Epaphroditus, the freedman of Nero, an individual of gross and vulgar habits. It is said that he was one day amusing himself in twisting the leg of his slave, when Epictetus exclaimed, "you will break it;" and the event justified the prediction. "I told you so," added the philosopher, without changing a muscle of his countenance. Of his personal history it may be readily imagined that we know but little; even his name is unknown to us, for Epictetus merely marks his condition of life, signifying in Greek *a slave* (επικτητος). He must, however, have received his freedom; for, when Domitian published his edict about the year 90, banishing philosophers from Italy, Epictetus retired to Nicopolis in Epirus, where it is supposed he passed the rest of his life. Spartianus indeed asserts that he lived at Rome in great intimacy with the Emperor Hadrian; but if this information be correct, he does not seem to have profited much by his intercourse with the rich, for his house is said to have been without a door, and to have had no furniture except a table, a bed, and a miserable mattress.

Epictetus was a Stoic, but possessed none of the vain boastings nor austerity of that sect of philosophy. The virtue which he prized most dearly was modesty. Being an enemy of Epicurus and his doctrines, he admired Socrates, and has left us a magnificent picture of the true cynic. As we might expect from his principles, Epictetus during the whole of his life made war on opinion. All his doctrines were reduced to this point: Our actions depend on ourselves; all other things are independent of us: let us therefore devote our whole attention to the correction and amendment of the first; but it is madness to make any effort to avoid the other, for they are entirely beyond our control. *Support pain and fly pleasure,* was the grand leading precept of Epictetus. It is indeed beautiful, but difficult to follow. Suidas says he wrote much, but nothing has come down to us. Arrian, the most celebrated of his disciples, collected, with much care and diligence, the discourses and principles of his master, and composed several treatises on them, viz. 1. On the Life and Death of Epictetus; 2. Twelve books of Familiar Discourses of this philosopher (these two works are lost); 3. Eight books of Dissertations on Epictetus and his Philosophy, four of which only remain; 4. Enchiridion, or Manual of Epictetus, which is preserved, and in which he presents a concise view of the moral philosophy of the Phrygian. Arrian dedicated this work to M. Valerius Messalinus, consul in the year of the city 901. There are also in Stobæus many moral sayings of Epictetus, which have been collected by Blancard, Copenhagen, 1629, 12mo. The first Greek edition of the Enchiridion was published at Venice, 1528, 4to. See also Heyne's edition with notes, Dresden, 1776, 8vo.

EPICUREAN Philosophy, the system of doctrine, canonical, physical, and ethical, taught by Epicurus, and maintained by his followers, who, from the name of their master, received that of Epicureans.

The first part of this threefold system regarded the canons or rules of judging. Disgusted with the subtle-

Epicurean Philosophy.

ties and paradoxes of the Stoics, Epicurus endeavoured to introduce a more simple and natural method of judging, and, instead of artificial modes and scholastic distinctions, appealed to the common sense and natural perceptions of mankind as the ultimate basis of all reasoning. These he assumed as first principles, or rather as unerring guides; and by giving excessive latitude to an elementary definition, which, if properly guarded and restricted, might have served as the foundation of a rational system of logic, he was betrayed into errors and extravagances not less startling than those from which it had been his object to escape. Cicero has reproached him with an alleged unphilosophical contempt of logic; but this censure, when duly weighed, must be pronounced to be entirely without foundation. Epicurus, it is true, despised and even ridiculed the modes of reasoning by means of which the Stoics evolved the paradoxes in which they delighted; and he was neither acquainted with nor had any relish for those analytical investigations in which the members of that philosophical sect displayed so much unprofitable ingenuity. But, on the other hand, all the errors with which his system is easily chargeable, may be traced to the logical strictness with which he adhered, in all his reasonings, to the primary canon which he had laid down, and to the implicit faith which he was consequently led to repose in those sensible perceptions and intuitive judgments which, though in every case relatively true, are nevertheless in many absolutely and demonstrably false. Having, as he conceived, established a principle indisputably certain, he was prepared to admit, and, in point of fact, never suffered himself to doubt or to question, any consequence, however startling, which might be logically deduced from it. His very errors, therefore, are the direct and necessary result of a rigid adherence to this principle, and of the precision with which he reasoned from the primary assumption to its consequences.

In the second or physical part of his system, Epicurus borrowed from Democritus and Leucippus the idea of the atoms or monads, which he regarded as the ultimate principles of all things. These atoms, however, which had no other properties than those of hardness and gravity, and which were therefore totally distinct from the gases of every kind that form so prominent a part of the physics and chemistry of the moderns, soon fell into discredit with philosophers; and, notwithstanding the poetical embellishments which the hypothesis received from the genius of Lucretius, it continued to be treated as a subject more fitted for ridicule than reason, until Gassendi endeavoured to revive and restore it, but without success. The efforts of this philosopher, however, can scarcely be considered as having proved altogether fruitless, since Leibnitz in his theory of monads, Boscovich in his principles of corpuscular attraction, and still more recently Dr Dalton in his theory of definite proportions, which has effected a complete revolution in the nomenclature of modern chemistry, have, each in succession, adopted modifications of the original hypothesis, and thus brought within the precincts of science a doctrine once regarded as amongst the wildest extravagances of ancient philosophy. In fact, the atomic theory of modern times is founded upon the same general principle with the hypothesis promulgated by Democritus, taught by Leucippus, and afterwards adopted by Epicurus; namely, that matter, so far from being infinitely divisible, is resolvable by division, decomposition, or analysis, into certain ultimate or primordial elements or atoms, which, again, enter synthetically, in certain definite proportions, into the constitution or composition of all things. And thus it is that the grand cycle of decay and reproduction, observable in the operations and changes which take place in the material world, may also be detected in the history of philosophical systems; they rise, decline, disappear, and are reproduced by the silent working of causes too remote to be discovered or appreciated by us; they have their various phases and occultations, even whilst they remain within the sphere of our observation; and when they altogether disappear from our view, and seem to be for ever lost, it is only to return, after having rounded their apogee, and to present nearly the same aspect as before.

With regard to the third or ethical part of this system, morality, according to Epicurus, is entirely founded upon utility. Man is placed upon earth to seek or pursue his own happiness or good, and he finds it only in a calm and tranquil life. The sage is ever upon his guard against the passions which might disturb his peace. Physical pleasure consists in the satisfaction of our natural wants; but the less trouble we take to ensure this satisfaction, the fewer privations we will be exposed to, and the greater will be our immunity from reverses of fortune. To abstain in order to enjoy, was accordingly the grand maxim of this philosopher. The happiness of individuals depends upon, and forms part of, the general happiness, from which, therefore, it can never be separated. This is his leading principle; and hence the essence of his ethical system consists in inculcating the *maxima felicitas*, or the greatest happiness of the greatest number. It has indeed been vulgarly alleged that Epicurus made the supreme good to consist in pleasure; and many persons persist in thus representing his doctrine, without giving themselves the trouble to inquire what he understood by pleasure; a term which, as he applied it, differs in no degree from the wisdom of the Stoics, and the *maxima felicitas* of the modern school of Utilitarians, founded by Bentham, the great restorer of the Epicurean ethical philosophy. In the nomenclature of this system, whatever contributes to the happiness and well-being of man as a member of society, is denominated pleasure; nor, as the happiness of individuals is made to depend upon, and declared to be inseparable from, the general happiness, can the true meaning of the term be mistaken or misapprehended by any honest and intelligent inquirer. But those false Epicureans, who limited the import of the word to mere sensual indulgence, and reasoned as if Epicurus himself had recognised this acceptation, did great injury to the sect, which they brought into unmerited discredit and odium. We accordingly find that they were banished from Rome in the time of the republic, and also, at different intervals, from a number of other cities. But the school always subsisted at Athens, where it remained in the time of Lucian; and Numenius, his contemporary, remarks, with an evident feeling of regret, that the Epicureans had preserved in all its purity the doctrine of their master, whilst that of Plato had been greatly altered and corrupted. The Stoics appropriated several of the maxims, and adopted the most remarkable apophthems of Epicurus, which are expressed, with much spirit, in a brief, sententious style; and the principal charm of Seneca's letters to Lucilius consists in the freedom and extent to which he has borrowed from the same source.

It is very difficult to discover the real opinion of Epicurus respecting the divinity. Cicero assures us that the philosopher spoke of the Supreme Being in terms the most sublime, and that he recommended piety to his disciples. It may no doubt be alleged that this was done in order to conform to the popular belief, and that no safe conclusion can be drawn, as to the opinion really entertained by the philosopher, from mere generalities, or a convenient and safe recommendation. But, on the other hand, in his letter to Menecius, Epicurus expresses himself thus: "The gods are not such as the vulgar believe; and the impious man is not he who rejects the gods of the multitude, but he who attributes to the gods the opinions of the multitude." These expressions, if they had been known, would have been sufficient to ensure to their author the honours of persecution. But, whilst it is evident that Epicurus was not actuated by mere prudence in making the belief of a God one of the principal dogmas of his philosophy, it must at the same time be admitted that his other opinions respecting the gods rendered this belief useless. For he regarded them as beings perfectly happy, impassible, and in no degree concerned about, or disposed to intermeddle with, human affairs,—as alike indifferent to, and incapable of, being affected by the good or evil of this world; and thus destroyed at once a providence, and the hope of future recompense or punishment. To this opinion, certainly one of the most discouraging and disastrous which can be maintained or promulgated, may be mainly ascribed the charge of atheism which was early preferred, and often subsequently reiterated, against this amiable and virtuous philosopher, whose life was as remarkable for its moral purity as those of some of his pretended followers were for their dissoluteness and profligacy.

EPICURUS, one of the most celebrated philosophers of antiquity, was descended of an illustrious family, that of the Philaides, which derived its origin from Philæus, grandson of Ajax. Neocles, his father, resided in Gargettium, a borough of Attica; but finding himself ill provided in point of fortune, he passed into the island of Samos, when the Athenians sent a colony thither, in the year 352 before Christ. As Diogenes Laertius fixes the birth of Epicurus in the year 341 before Christ, it is therefore probable that the philosopher first saw the light at Samos, and not at Gargettium, as is commonly supposed. In his early youth he is said to have followed his mother, who appears to have been an itinerant sorceress, reading the formularies of exorcism and expiation, whilst she performed the ceremonies usual on such occasions; but as he advanced in years he assisted his father in keeping a school, which the latter had established at Samos. At the age of fourteen Epicurus began to devote himself to philosophy. He at first attended Pamphilus, one of the disciples of Plato, and Nausiphanes, of the school of Democritus; not the disciple of Pyrrho, as Diogenes Laertius affirms, Pyrrho having been the contemporary of Epicurus. But the lessons he received from these teachers did not satisfy his mind; and having applied himself to the study of the writings of Democritus, he made great progress in philosophy, and soon thought himself in a condition to form a new sect. At the age of eighteen he proceeded to Athens, but he sojourned there only a short time, by reason of the troubles which ensued after the death of Alexander. He then repaired to his father's at Calophon, in Ionia, whence he afterwards went to Mitylene and Lampsacus, where he began to profess his new principles of philosophy. Having attracted a great number of disciples, amongst whom were the three brothers Neocles, Cheredemus, and Aristobulus, he returned with them to Athens in the year before Christ 309; and having there purchased a garden for eighty minæ, or L.288 sterling, he immediately commenced teaching his philosophy. All the world was not admitted to his lessons; but his disciples, in imitation of the Pythagoreans, formed a sort of community by themselves. Nevertheless, he did not recommend or encourage a community of goods, which he considered as calculated to excite distrust; but each paid a portion of the general expense, which, however, was inconsiderable, as they were content with the simplest fare. The most perfect union reigned amongst them, and indeed subsisted undisturbed long after the death of Epicurus. Cicero says that the Epicureans of his time still lived in common, and in the best understanding with one another. Women were even admitted into this society; and amongst its most celebrated disciples are mentioned Leontium, courtezan of Athens, and Themista, wife of Leontius of Lampsacus. As Epicurus never taught in public, the sect was little celebrated during his lifetime; but after his death, when his writings became generally known, the doctrine therein taught was warmly attacked by the Stoics, who did not blush even to have recourse to the most atrocious calumnies. Diotimus the Stoic went so far as to fabricate, in the name of Epicurus, fifty letters addressed to courtezans, in which the philosopher is made to express himself in the most obscene manner; but Chrysippus himself bears testimony to the blameless conduct and manners of Epicurus; and although the latter alleged that this was not the result of philosophy, but attributable solely to coldness and insensibility of temperament, it is certain that his life was wholly free from those vices with which his enemies have reproached him. For a short account of the system, canonical, physical, and ethical, taught by this philosopher, see EPICUREAN PHILOSOPHY. Epicurus died of the stone in the seventy-second year of his age. He was never married; not that he blamed marriage, for he taught that a wise man ought to marry and have children; but as he was of a feeble constitution, and seldom enjoyed good health, he did not think it incumbent on him to observe the maxim which he inculcated on others. By his will, which Diogenes Laertius has preserved, he bequeathed his garden and a house which he had at Melitus to Hermachus his successor, and to those who should after him be at the head of his school, as long as it should subsist, in order that his followers might assemble on the spot where his system was first taught. His memory was held in veneration by his disciples, among whom the anniversary of his birth was celebrated as a festival; they had his portrait engraved on their rings and on their cups, as well as placed in their chambers; and they never spoke of him but with the greatest respect. In the number of Greek manuscripts discovered at Herculaneum have been found several of the works of Epicurus, the unravelling of which, however, has as yet been only partially effected. Some fragments of the second book of his treatise *On the Nature of Things* were published at Naples in 1814. No one has better developed the philosophical system of Epicurus than Gassendi in his *Syntagma de Vita et Moribus Epicuri*, lib. viii. Lyons, 1647. See also Durondel, *Vie d'Epicure*, Paris, 1679; Coutures, *La Morale d'Epicure*, Paris, 1685; *Apologie pour Epicure*, and *Discours sur Epicure*, Paris, 1651 and 1684, in 12mo.

EPICYCLE, in the ancient astronomy, a little circle whose centre is in the circumference of a greater circle: or it is a small orb or sphere, which being fixed in the deferent of a planet, is carried along with it; and yet, by its own peculiar motion, carries the planet fastened to it round its proper centre.

It was by means of epicycles that Ptolemy and his followers solved the various phenomena of the planets, but more especially their stations and retrogradations.

EPICYCLOID, in *Geometry*, a curve generated by the revolution of the periphery of a circle, along the convex or concave side of the periphery of another circle.

EPIDAMNUS, afterwards called by the Romans DYRRHACHIUM, a city of Illyria, on the coast of the Adriatic, founded by a colony from the island Corcyra, under the command of Phalius, a native of Corinth, 629 years B. C. according to Eusebius. The lofty and precipitous peninsula on which it was built seems to have been called Dyrrhachium; and as the last syllable of Epidamnus was significant of ill omen to the Romans, that superstitious people

Epidaurus.

were probably induced to change it for the name applied by the Greeks to the peninsula. There seems no good reason to believe that the site of the more modern town was different from that of the ancient. Epidamnus became at a very early period of considerable importance: its intimate connection with the rich republics of Corcyra and Corinth excited in its citizens a spirit of commercial enterprise; and it was not long before they rivalled the most celebrated of the cities of Greece in the extent of their trade and the magnitude of their undertakings. Epidamnus continued to prosper until it became a prey to domestic feuds and civil broils. Its constitution was originally aristocratic; a single magistrate formed the head of the administration; and the phylarchs (φυλαρχαι) composed a species of council. These phylarchs were afterwards replaced by a senate (βουλη) chosen on democratic principles. It was the contest between the popular party at Epidamnus and the nobles that produced the Peloponnesian war. Corcyra refused to interfere, and the Epidamnians proceeded to make their application to the Corinthians, who felt nowise disinclined to increase their own power at the expense of the Corcyreans. The aid furnished by Corinth soon re-established order and tranquillity; but the Corcyreans, at no time on good terms with that city, felt highly indignant that it should have interfered with what they considered as their own peculiar property. They sent orders to the Epidamnians to receive back the nobles whom they had banished, and to cause the Corinthians to evacuate the city; but as no attention was paid to the demand, they equipped a fleet, and, in conjunction with a body of Illyrians, besieged the town, which, in a few days, was compelled to surrender. This was the beginning of the Peloponnesian war. Of the subsequent history of Epidamnus we know but little until we find it under the protection of the Romans, to whom it adhered faithfully, both in the Illyrian and Macedonian wars.

At a later period it became the scene of contest between Pompey and Cæsar; but for a detailed account of these transactions we must refer the reader to the Commentaries of Cæsar himself. From this time it became much frequented by the Romans, from being situated at the commencement of the great Egnatian Road, which led through Macedonia to the provinces of the east. Here it was that Cicero landed on his banishment from Italy; and he speaks in high terms of commendation of the kind treatment which he received from its inhabitants. At the end of the fourth century Dyrrhachium became the capital of the newly established province of Epirus Nova; and it is now called *Durazzo*, which is an insignificant village, rendered unhealthy by its vicinity to marshes.

EPIDAURUS, a city of Argolis, in the Peloponnesus, situated in a recess of the Saronic Gulf, open to the north-east, and backed by high mountains, was founded probably by Carians, and afterwards joined by a colony of Ionians from Attica. It was at first subject to Argos; but on the return of the Heraclidæ and Dorians to the Peloponnesus, an independent kingdom was established, which extended over the whole of this small peninsula. We find its king Procles engaged in war with Periander of Corinth. In the Persian war it sent ten ships to the common fleet at Salamis, and eight hundred heavy-armed men to Platæa· and in the Peloponnesian war it always appears as the determined opponent of Argos, and the ally of Sparta, successfully resisting the Argives when besieged by them after the battle of Amphipolis. In the time of Augustus the circumference of its walls was no more than fifteen stadia; whence it appears that Epidaurus was even at that time reduced to the promontory where are now to be seen, in many parts, the foundations of Hellenic walls along the edge of the cliffs. A small neighbouring village is still called *Pidhavro*.

Epidaurus was chiefly remarkable for the temple and sacred grove of Æsculapius, one of the most renowned places in Greece for its sanctity, riches, and the splendour of the sacred offerings which adorned it. It was at the distance of five miles from the city, and surrounded by a semicircle of steep hills. The place is still called *Sto Ierò*, which means the temple, or sacred place. It contained a statue of the god, wrought in gold and ivory, by Thrasymedes of Paros, and about half the size of the Jupiter Olympius at Athens. Æsculapius was seated on a throne, holding a staff in one hand, whilst the other rested on the head of a serpent, and a dog lay at his feet. Beside the temple was the dormitory of those who came to supplicate the god; and near it the Tholus, a circular building of white marble, built by Polycletus of Argos. But the most remarkable building was the theatre, which, though inferior in size and ornamental decoration to those of the Romans, far excelled them in the beauty of its workmanship and the harmony of its proportions. This temple was the most fashionable place of resort for Grecian invalids seeking relief from a change of air, of place, or of medical treatment. Hither they flocked from every part of the country, to place themselves under the care of the servants of Æsculapius; and those who were healed were in the habit of recording their cures with inscriptions in different parts of the temple.

Considerable remains of the temple and adjoining buildings are still to be seen. "There exists a part of the foundations, and some remains of the circular cell of the Tholus, with defaced inscriptions. But the most remarkable ruin at Iero is the theatre: though no traces of the proscenium remain, and many of the seats made of white marble are displaced, it is in better preservation than any other theatre in Greece, except that which exists near Trametzus in Epirus, not far from Joannina. The orchestra must have been about ninety feet in length, and the entire theatre about 370 in diameter. Thirty-two rows of seats still appear above ground in a lower division. The theatre, when complete, was capable of containing 12,000 spectators." Leake's *Travels in the Morea*, vol. ii. p. 424, London, 1830.

EPIDEMIA, in Grecian antiquity, festivals observed in honour of Apollo and Diana, at the stated seasons when those deities, who could not be present everywhere, were supposed to visit different places, in order to receive the vows of their worshippers.

EPIDEMIC, among physicians, an epithet applied to those diseases which at certain times are popular, attacking great numbers at or near the same time. See MEDICINE.

EPIDERMIS, in *Anatomy*, the cuticle or scarf-skin. See ANATOMY. The word is formed of the Greek επι, *on*, *over*, and δερμα, *skin*.

EPIDICASIA, amongst the Athenians. Daughters inheriting their parents' estate were obliged to marry their nearest relation; which gave occasion to persons of the same family to go to law with one another, each pretending to be more nearly allied to the heiress than the rest. The suit was called επιδικασιας δικη; and the virgin about whom the relations contested, επιδικος.

EPIDOTÆ, certain deitics who presided over the growth of children. They were worshipped by the Lacedæmonians, and chiefly invoked by those who were persecuted by the ghosts of the dead, or spectral apparitions.

EPIGONI, the sons and descendants of the Grecian heroes who were killed in the first Theban war. The war of the Epigoni is famous in ancient history. It was undertaken ten years after the Theban war. The sons of those who had perished in that contest resolved to avenge the death of their fathers, and marched against Thebes, under the command of Thersander, or, according to others, of Alcmæon the son of Amphiaraus, about 1307 years before Christ. The Argives were assisted by the Corinthians and the people of Messenia, Arcadia, and Megara. The Thebans had engaged all their neighbours in their quarrel, as in one common cause. The two hostile armies met on the banks of the Glissas, and a battle ensued. The combat was obstinate and bloody; but victory declared for the Epigoni, and some of the Thebans fled to Illyricum with Leodamas their general, whilst others retired into Thebes, where they were soon afterwards besieged and forced to surrender. In this war Ægialeus was the only person of note who was killed; and in the former his father Adrastus was the only individual of this description who escaped alive. This whole war, as Pausanias observes, was written in verse; and Callinus, who quotes some of the verses, ascribes them to Homer, an opinion which has been adopted by many writers. "For my part," continues the geographer, "I own, that next to the Iliad and Odyssey of Homer, I have never seen a finer poem." The *Epigoniad* of Wilkie is a modern poetical celebration of the same story. The descendants of the veteran Macedonians, who served under Alexander the Great, and who had children by Asiatic women, were also called Epigoni.

EPIGRAM, in *Poetry*, a short poem in verse, treating only of one thing, and ending with some lively, ingenious, and natural thought or point. The word is formed of επιγραμμα, *inscription*, from επιγραφειν, *to inscribe* or *write upon*. See POETRY.

EPIGRAPHE, among antiquaries, denotes the inscription of a building, pointing out the time when, the persons by whom, and the uses for which, it was erected.

EPILOGUE, in *Oratory*, the end or conclusion of a discourse, ordinarily containing a recapitulation of the principal matters before delivered.

EPILOGUE, in the *Drama*, a speech addressed to the audience after the play is over, by one of the principal actors, and usually containing some reflections on certain incidents in the play, especially those in the part of the person who speaks it, together with somewhat of pleasantry, intended to compose the passions raised in the course of the representation; a practice which is ridiculed by the *Spectator*, and compared to a merry jig upon the organ after a good sermon, in order to wipe away any impressions that might have been thereby produced, and to send the people away just as they came.

EPIMENIDES, a native of Gnossus in Crete, who seems to have flourished about 594 B. C. and of whom we have several very extraordinary accounts. Being probably a man anxious to distinguish himself, he was not long in perceiving that the readiest way to obtain the object he had in view was to work on the love of the supernatural, a feeling inherent in the minds of an ignorant people. Accordingly we are told that he retired from all intercourse with his countrymen, and no doubt devoted himself to the acquisition of that knowledge which enabled him to act the part which he had chalked out for himself. When he imagined his name forgotten, he re-appeared with his hair and beard long and matted, and spread a report that he had slept upwards of two hundred and ninety years. Who does not recognise in this the story of the seven sleepers? In accordance with this spirit of charlatanry, he pretended to the gift of prophecy, and to intimate converse with the gods. Yet under all this outward garb of fanaticism he seems to have concealed a profound knowledge of mankind, and to have employed the influence he had acquired in obtaining the sanction of the Cretans to a code of laws constructed on just and sound principles. His fame became so widely spread, that Solon, under pretence of purifying the city of Athens from the blood shed in consequence of civil feuds and dissensions, determined to make use of his influence to prepare the way for the laws which he wished to introduce. A vessel was equipped, and Epimenides having acceded to the invitation given him, assisted in purifying the city, and at the same time prepared the way for the legislation of Solon. He wrote several works, of which the most considerable was a poem on the expedition of the Argonauts; but none of these has come down to us. His life has been written by Diogenes Laertius, but that writer is too credulous to admit of our placing much dependence on the facts he states. See Cic. *Div.* i. 18, and *Leg.* ii. 2; Val. Max. viii. 5; Suidas; Plato *De Leg.*; Pausanias; also, for his age, Vossius *De Hist. Græc.* Lug. Bat. 1651; Fabricius, *Biblioth. Græc.* i. 6.

EPIMETHEUS, a son of Japetus and Clymene, one of the Oceanides, who inconsiderately married Pandora, by whom he had Pyrrha, the wife of Deucalion. He had the curiosity to open the box which Pandora had brought with her, and thence issued the train of evils which from that moment have never ceased to afflict the human race. Hope was the only redeeming ingredient which remained at the bottom of the box, not having had sufficient time to escape; and she it is alone who comforts men under misfortunes. Epimetheus was changed into a monkey by the gods, and sent into the island Pithecusa.

EPINAL, an arrondissement of the department of the Vosges, in France, extending over 550 square miles, and divided into five cantons, which are subdivided into 116 communes, with 68,610 inhabitants. The capital, a city of the same name, is situated on the river Moselle, which divides it into two parts. It is a well-built place, containing 1100 houses and 7820 inhabitants, who carry on some trade in earthenware, cotton goods, paper, and leather. Long. 6. 29. E. Lat. 48. 22. N.

EPIPHANIUS, ST, an ancient father of the church, born at Besanducan, a village in Palestine, about the year 332. He founded a monastery near the place of his birth, and presided over it. He was afterwards elected bishop of Salamis, when he took part with Paulinus against Meletius, and ordained in Palestine Paulinian, the brother of St Jerome, on which a contest arose between him and John bishop of Jerusalem. He afterwards called a council in the island of Cyprus, in which he procured a prohibition of the reading of Origen's writings, and made use of all his endeavours to prevail on Theophilus bishop of Alexandria to engage St Chrysostom to declare in favour of that decree; but not meeting with success, he himself proceeded to Constantinople, where he refused to have any conversation with St Chrysostom, and formed the design of entering the church of the apostles to publish his condemnation of Origen. Being informed, however, of the danger to which he would be exposed, he resolved to return to Cyprus, but died at sea in the year 403. His works were printed in Greek at Basil, 1544, in folio, and were afterwards translated into Latin, in which language they have often been reprinted. Petavius revised and corrected the Greek text with the aid of two manuscripts, and published it together with a new translation at Paris in 1622. This edition was reprinted at Cologne in 1682.

EPIPHANY, a Christian festival, otherwise called the *Manifestation of Christ to the Gentiles*, observed on the sixth of January, in honour of the appearance of our Saviour to the three magi or wise men, who came to adore him and bring him presents. The feast of epiphany was not originally a distinct festival, but formed part of that of the nativity of Christ, which being celebrated twelve days, the first and last of which were high or chief days of solemnity, either of these might properly be called *epiphany*, as that word signifies the appearance of Christ in the world.

The word in the original Greek, επιφανια, signifies *appearance* or *apparition*, and, as some critics think, was applied to this feast, on account of the star which appeared to and guided the magi. St Jerome and St Chrysostom take the epiphany for the day of our Saviour's baptism, when he was declared to men by the voice, *Hic est filius meus dilectus, in quo mihi complacui*, this is my beloved Son, in whom I am well pleased; and accordingly it is still observed by the Copts and Ethiopians in this view. But others contend that the feast of Christmas, or the nativity of our Saviour, was held in different churches on this day, which had the denomination *epiphany* or *appearance*, by reason of our Saviour's first appearance upon earth at that time. And it must be allowed that the word is used amongst the ancient Greek fathers, not to signify the appearance of the star to the magi, but that of our Saviour to the world; in which sense St Paul uses the word *epiphania* in his second epistle to Timothy (i. 10.)

EPIRUS, a country to the north-west of Greece, along the coast of the Ionian Sea, bounded on the north by the Ceraunian Mountains, on the south by the Ambracian Gulf, and separated on the east and north-east from Thessaly and Macedonia by the lofty range of Pindus. This extensive country was known in the earlier ages of the world under no general name; it was probably the inhabitants of the numerous islands along its coasts who first applied to it the appellation of Epirus, answering to the English term mainland, in order to distinguish it from the islands which they themselves inhabited. It included within its bounds several nations, the most powerful of whom were the Molossi, whose chief town was Dodona, famous for the oracle and temple of Jupiter; the Thesproti, who had for their capital Buthrotum; and the Chaones, who dwelt in the valleys of the Ceraunian Mountains. All these tribes are considered as having been of Pelasgic origin. Though allied by blood with the Greeks, they were always regarded as barbarians, and Ambracia as the last city in Greece. The ancient buildings, institutions, and religious worship of the Epirotes, are also manifestly of Pelasgic origin.

The kings of Epirus pretended to be descended from Pyrrhus, son of Achilles, who settled in this country after the taking of Troy, and transmitted his kingdom to Molossus, his son by Andromache; but the early history of the kings of the Molossi is involved in much obscurity. Admetus sat on the throne of Epirus, 480 B. C. at the time of the invasion of Greece by the Persians, and he remained neutral till their defeat, when he solicited an alliance with the Athenians. This was refused chiefly through the persuasion of Themistocles; yet Admetus was generous enough to forget this circumstance when Themistocles was banished, 471 B. C. by his ungrateful countrymen, and received him with every mark of respect and esteem.

Admetus was succeeded by his son Tharymbas or Arymbas I. about 429 B. C., but was still so young that he was placed, by a decree of the people, under the guardianship of Sabylinthus, prince of Atintania. He seems to have been a wise and prudent monarch, who attempted to introduce a regular form of government among a wild and a lawless people. Alcetas is the next king of Epirus mentioned in history, and he reigned about 385 B. C. Being driven from his throne by his subjects, he fled to Syracuse, and with the assistance of Dionysius was soon afterwards re-established. Neoptolemus his son reigned but a short time, and left the crown to his brother Arymbas II. about 360 B. C. who encouraged literature and the arts, governing his kingdom with prudence, equity, and moderation. It was to him that Xenocrates of Chalcedon dedicated the four books which he had composed on the art of governing. This prince educated with the greatest care the children of his brother. He married Troas, one of his nieces, and gave the other, Olympias, in marriage to Philip of Macedon, who had by her Alexander the Great. On his death, 342 B. C. he was succeeded by his nephew Alexander, brother of Olympias. This prince was put in possession of the throne of his uncle by the aid of his brother-in-law Philip, who afterwards gave him in marriage his daughter Cleopatra. It was at the celebration of these nuptials at Edessa that the king of Macedonia was assassinated.

Alexander was the first prince who raised the character and reputation of his country amongst foreign nations. Having been applied to by the Tarentines for assistance against the Samnites and Lucanians, he passed into Italy with a considerable force, made a descent at Pæstum, 332 B. C., a city near the mouth of the river Silarus, and reduced under his dominion several cities of the Lucani and Brutii. In his second attack upon Italy he was surrounded by the enemy, defeated, and slain, near the city Pandosia, in the territory of the Brutii.

Œacides the son of Arymbas II. succeeded to Alexander, and espoused the cause of Olympias against Cassander; but his soldiers having mutinied, dethroned him, though he was in a short time reinstated. He was killed the same year, 313 B. C., in a battle against Philip, brother of Cassander. This prince had by his wife Phthia, the celebrated Pyrrhus, and two daughters, Deidamia and Troas, of whom the former married Demetrius Poliorcetes. His brother Alcetas, who succeeded him, continued the war with Cassander till he was defeated, and his dominions were overrun by the enemy. He was afterwards put to death by his rebellious subjects 295 B. C. The name of Pyrrhus, who now ascended the throne, sheds a lustre on the annals of Epirus, and gives to its history an importance which it would never have otherwise possessed; but for a detailed account of his life we must refer to the article PYRRHUS.

Alexander, in 272 B. C., succeeded his father Pyrrhus, when he attempted to seize on Macedonia. He defeated Antigonus Gonatas, but was himself shortly afterwards driven from his kingdom by Demetrius, son of that prince. He recovered it, however, and spent the rest of his reign in peace. At the expiration of two other insignificant reigns the family of Pyrrhus became extinct, upon which the inhabitants of Epirus changed the form of their government, electing annually a prætor in a general assembly of the nation held at Passaron, a city of the Molossi. Epirus imprudently espoused the cause of Perseus in his war against the Romans, when he was defeated and taken prisoner 168 B. C.; and it was exposed to the unrelenting fury of the Romans, who destroyed in one day seventy-three cities, and carried away the principal inhabitants to Rome. It never recovered from this fatal blow. At the dissolution of the Achæan league, 146 B. C. this country became part of the province of Macedonia under the name of Vetus Epirus, in order to distinguish it from Nova Epirus, which lay to the east.

On the division of the empire it became the inheritance of the emperors of the East, and remained under them until the taking of Constantinople by the Latins, in 1204, when Michel Comnenes seized on Ætolia and Epirus. On the death of Michel, in 1216, these countries fell into the hands of his brother Theodore. Charles, the nephew of Theodore, and the last prince of this family, having died without legitimate heirs, Epirus and Acarnania were left to his natural children. Amurath II. stripped them of this inheritance. In 1443, Scanderberg, king of Albania, made himself master of a considerable part of Epirus. But on his death it fell into the power of the Venetians, from whom it passed to the Turks, who possess it at present under the name of Albania.

EPISCOPACY, that form of church government in which diocesan bishops are established, as distinct from and superior to priests or presbyters. We have already observed, that from a very early period the ministers of religion have been distinguished into different orders, and that it has been much controverted whether the distinction be of divine or human right; whether it was settled in the apostolic age, or only adopted afterwards. (See Bishop.) This controversy commenced soon after the Reformation, and has been agitated with great warmth between the Episcopalians on the one side, and the Presbyterians and Independents on the other. Amongst the Protestant churches abroad, those which were reformed by Luther and his associates were in general episcopal; whilst such as follow the doctrines of Calvin have for the most part dispensed with the order of bishops, as being either unnecessary or unattainable. In England, however, the controversy has been considered as of greater importance than on the continent; for it has there been strenuously maintained by one party that the episcopal order is essential to the constitution of the church; and by the others, that it is a pernicious encroachment on the rights of Christians, for which there is no warrant or authority in Scripture. Though the question has for some time lain almost dormant, and though we have no desire to revive it, yet as a work of this kind might perhaps be deemed defective, did it contain no account whatever of a controversy which has employed some of the ablest writers of the past and present times, we shall give a fair though short view of the chief arguments by which the advocates of each contending party have endeavoured to support their own cause, leaving it to our readers to judge where the truth lies. See Independents and Presbyterians.

The Independent maintains, that under the gospel dispensation there is nothing which bears the smallest resemblance to an exclusive priesthood; that Christ and his apostles constituted no permanent order of ministers in the church; but that any man who has a firm belief in revelation, a principle of sincere and unaffected piety, a capacity for leading devotion and communicating instruction, and a serious inclination to engage in the important employment of promoting the everlasting salvation of mankind, is in all respects a regular minister of the New Testament, especially if he have an invitation to the pastoral office from some particular society of professing Christians.

Against this scheme, which supposes the rights and privileges of all Christian men to be equal, and which acknowledges no authority in the church excepting that which is derived from election by its members, the Protestant Episcopalian argues in the following manner: He admits, as an undoubted truth, that Christ gave to none of his followers authority or jurisdiction of such a nature as could interfere with the rights and duties of the civil magistrate; that he never conferred upon them what he disclaimed for himself, when, before Pilate, he declared that his kingdom was not of this world. He maintains, however, that Christ did confer upon his immediate followers, and does still confer upon their successors in the ministry, authority and jurisdiction of a specific nature over other Christians; and that neither during our Saviour's abode upon earth, nor during the period of the government of the church by apostles, nor in the age immediately succeeding these, did there exist an absolute equality among believers.

During our Saviour's ministry, it will be allowed that all power resided in him; and it is important to observe, that even then, before believers were constituted a church, parity was abolished by the ordinance of Jesus himself, in the appointment of the twelve apostles and the seventy disciples. And when the divine Founder of Christianity was making preparations for the maintenance of his religion after his departure hence, he did not abolish the distinction which he had previously instituted, but granted to the twelve apostles a still wider commission, a still more decided supremacy over the ordinary members of the church. "As my Father hath sent me," said he, "even so send I you. And when he had said this, he breathed on them, and said unto them, receive ye the Holy Ghost: whose soever sins ye remit, they are remitted unto them, and whose soever sins ye retain, they are retained." (John, xx. 21, 22, 23.) "All power is given unto me in heaven and in earth. Go ye, therefore, and teach all nations, baptizing them in the name of the Father, and of the Son, and of the Holy Ghost, teaching them to observe all things whatsoever I command you; and lo, I am with you alway, even unto the end of the world." (Matt. xxviii. 18, 19, 20.) Now the Episcopalian maintains that men who had received this commission could not be on a footing of equality as to ecclesiastical privileges with the great body of believers, who had no commission whatsoever.

If, however, all this be granted, and still the *permanence* of the commission be denied, the Episcopalian refers to our Lord's concluding words, "I am with you alway, even unto the end of the world;" and asks how Christ could be with the commission to the end of the world, if the commission itself was to last only for one generation. But, further than this, he refers to the acts of the apostles, as furnishing abundant evidence that they understood it to be the will of Christ that there should be a perpetual succession of privileged officers in the church. For, in the first place, the vacancy occasioned by the death of Judas was immediately filled by the appointment of Matthias; then a new order of Christian ministers was introduced under the name of deacons; afterwards Barnabas and Saul were ordained to be apostles; and finally, as the number of Christian congregations increased, a race of ministers superior to the deacons was instituted, to administer the sacraments, and to preside in the religious assemblies. To imagine that these were elected by the laity, and derived their authority from that election, could scarcely be credited, even if we possessed no evidence to the contrary. But St Paul (Eph. iv. 11) asserts, that when Christ ascended up on high, "*He* gave some apostles, and some prophets, and some evangelists, and some pastors and teachers;" that is to say, *he* commissioned the apostles, and empowered *them* to commission the inferior officers.

With respect to the age immediately succeeding the apostolic, we cannot of course refer to Scripture, but must have recourse to the records of primitive antiquity. And in referring to the *Fathers* for the historical fact, the Episcopalian claims for them nothing more than sufficient honesty to tell the truth when there existed no temptation to commit falsehood, or sufficient sense to abstain from a falsehood which it was impossible should be credited by any of their contemporaries. Now, of the earliest Christian writers, of those called apostolic fathers, because they are believed, on good grounds, to have been contemporaries and companions of the apostles, three, namely, Clement of Rome, Ignatius, and Hermas, explicitly state the existence of different orders of officers in the church, to whom great honour and obedience was due from the laity; whilst the remaining two, Polycarp and Barnabas, do not touch upon ecclesiastical polity. Further than this it is unnecessary to descend, as every one now admits that in the age succeeding this, diocesan episcopacy prevailed over the Christian world, and continued undisputed till the Reformation.

Against this historical argument it may be urged, that the commission to the apostles was " to go and teach all nations, baptizing them in the name of the Father, the Son, and the Holy Ghost;" and that consequently a system which confines the right of preaching and baptizing to their successors in a particular *order* appears inconsistent with the wisdom and the goodness of God; as by such an economy an intolerable dominion would be established over the souls of men, and the very purpose for which the Saviour died might be defeated by the caprice of an ignorant or designing priesthood. To this objection the Episcopalian replies, that under the Mosaic law sacrifice was necessary for the expiation of sin, but that in many most important cases this expiation could be effected only by the instrumentality of a priest; that, in short, the objection, if it have any weight, weighs with equal force against the wisdom and justice of Providence in the ordinary government of the world. In every thing, he observes, that is valuable, whether of a temporal or a spiritual nature, mankind are subjected to mutual dependence; baptism must be conferred, and knowledge must be communicated, by some human being; and it is just as easy to imagine the whole *human race*, as the whole *clerical order*, unfaithful to their obligations.

The Episcopalian having by arguments of this nature attempted to prove that Christ did institute a *permanent order of ministers* in his church, proceeds, in the next place, by an inquiry of the same nature, to prove that this order was not *single*, but *threefold*. In the former inquiry he was united with the *Presbyterian* against the *Independent;* he has now to answer the arguments of the Presbyterian, who maintains that originally the Christian church contained no office higher than that of *presbyter* or *elder;* and, in opposition to him, the Episcopalian maintains that Christ and his apostles instituted divers orders in the church, of which that of *bishops* with authority over *presbyters*, and with the *exclusive right of ordination*, was the highest.

In behalf of the Presbyterian plea it is urged, that the titles of *bishop* and *presbyter*, being in the New Testament indifferently given to the same persons, cannot be the titles of distinct ecclesiastical officers; which appears still more evident from the ordination of Timothy, who, although he was the first *bishop* of Ephesus, received his episcopal character by the imposition of the hands of the *presbytery*. That one and the same man is, in the New Testament, styled sometimes a *bishop* and sometimes a *presbyter*, cannot be denied; but although every apostolic bishop was therefore undoubtedly a presbyter, it does not of course follow, says the Episcopalian, that every presbyter was likewise a *bishop*. In the *Old* Testament, Aaron and his sons are without any discrimination of order frequently styled *priests;* and in the *New*, both St Peter and St John call themselves *presbyters*, as St Paul, upon one occasion, styles himself a *deacon*, διακονος (Eph. iii. 7): yet no man ever supposed those apostles to have been such ecclesiastical officers as modern presbyters and deacons; and it is universally known, that in the Jewish priesthood there were different orders, and that Aaron was of an order superior to his sons. This being the case, the presbyters, by the laying on of whose hands Timothy was made a bishop, *may have been* of the same order with St Peter and St John; and if so, it follows that his ordination was *Episcopal*. At all events, we are certain, continues the advocate for Episcopacy, that it was not in the modern sense of the word *Presbyterian;* for the gift, which in the first epistle is said to have been " given by prophecy *with* the laying on of the hands of the presbytery," is in the second said to have been " in him *by* the putting on of the hands of St Paul." And here it is worthy of observation, that the preposition used in the former case is μετα, which signifies *concurrence* rather than instrumentality; but *that* in the latter is δια, which, as every Greek scholar knows, is prefixed to the *instrumental cause* by which any thing is effected; so that whatever may have been the order of the presbyters who *concurred*, St Paul appears to have been the *sole* ordainer. But by the confession of all parties, St Paul was a bishop in the highest sense in which that word is ever used; and the powers of the episcopate not being parcelled out among various partners, of whom each possessed only a share, the imposition of his hands was sufficient for every purpose which could have been effected by the hands of the whole college of apostles.

It appears, therefore, that from the promiscuous use of the titles *bishop* and *presbyter*, and from the *ordination of Timothy*, nothing can with any certainty be concluded on either side of this celebrated question. But if, instead of resting on mere *words*, which, when taken alone and without regard to the context, are almost all of ambiguous signification, we attend to some important *facts* recorded in the New Testament, the Episcopalian thinks we shall discover in these sufficient evidence that the government of the primitive church was Episcopal.

During our Saviour's stay upon earth, it is undeniable that he had under him two distinct orders of ministers, the twelve and the seventy; and after his ascension, immediately before which he had enlarged the powers of the *eleven*, we read of *apostles*, *presbyters*, and *deacons*, in the church. That the presbyters were superior to the deacons, and the apostles superior to both, is acknowledged by the supporters of presbyterian parity; but it has been said, that in Scripture we find no intimation that the apostolic order was designed for continuance. A Quaker says the same thing of water-baptism; and the Episcopalian observes, that it would be difficult to point out by what passage of Scripture, or what mode of reasoning, those who upon this plea reject the apostolic order of Christian ministers, could overthrow the principles upon which the disciples of George Fox reject the use of that rite which our Saviour instituted for the initiation of mankind into his church. They were the *eleven* alone to whom Christ said, " go ye therefore and teach all nations, baptizing them in the name of the Father, and of the Son, and of the Holy Ghost;" and hence, although we frequently find presbyters and deacons administering the sacrament of baptism, we must conclude, that as a *judge* administers justice by authority derived from his *sovereign*, so those *inferior officers* of the church administered baptism by authority derived from the *apostles*. Indeed, had they pretended to act by any other authority, it is not easily to be conceived how *their* baptism could have been the baptism instituted by Christ; for it was not with the *external washing*, by whomsoever performed, but with the *eleven* and their successors, that he promised to be " always, even unto the end of the world."

We have already noticed that the *eleven*, acting, as all orthodox Christians allow, by the extraordinary direction of the Spirit, never appear to have supposed that the commission with which they were invested was to terminate with them. On the contrary, they admitted Matthias, Barnabas, and Paul, to the name and authority of apostles, and Timothy and Titus to some office which, it is evident, was superior to that of either ancient or modern presbyters. Supposing it then granted that Timothy was commissioned by the apostle Paul not to found a church where the gospel had been hitherto unpreached, but to execute some office in one previously founded, the Episcopalian maintains that the directions given by the apostle could be addressed to none but a bishop, that is, to one possessing an ecclesiastical authority superior to that of presbyters. For in Timothy (iv. 2–6) we read, "I besought thee to abide still at Ephesus, when I went into Macedonia, that thou mightest charge some that they teach no other doctrine, neither give heed to fables and endless genealogies. Let the presbyters that rule well be counted worthy of double honour; especially they who labour in the word and doctrine. Against a presbyter receive not an accusation but before two or three witnesses. Them that sin rebuke before all, that others also may fear. Lay hands suddenly on no man, neither be partaker of other men's sins." Now, an individual right to direct *presbyters* as to the doctrine they preached, to receive accusations against them, to rebuke the offending, to confer authoritative approbation upon the deserving, and finally, to *ordain*, are exactly the offices which belong to a bishop. The right to perform these, if derived from an appointment by presbyters, would have constituted a *superintending presbyter;* but the right being conferred by apostolic authority, raised their professor to higher *order*, and this higher order is the Episcopal.

It is unnecessary to pursue the argument in the case of Titus, bishop of Crete, whose episcopacy is equally clear with that of Timothy; and if no other diocesan bishops are mentioned in the Acts or Epistles, we need not wonder when we reflect how little is said of the greater part of the apostolic body.

We perceive, then, that as far down as the history of the church is warranted in Scripture, there always existed *imparity* among the ministers of religion, and that the apostles ordained certain officers to superintend or be *bishops* over the presbyters. And when from the inspired penmen of the New Testament he proceeds to examine the succeeding writers of the Christian church, the Episcopalian finds such multiplied and concurring evidence of the apostolic institution of episcopacy, as he thinks it impossible to resist without denying the truth of all ancient history, and even shaking the pillars of revelation itself; for, "in the noble army of martyrs," the witnesses of the episcopal government of the church are earlier, and by far more numerous, than those who testify that the gospel of St Matthew was written by that apostle, or that the book of the Apocalypse is canonical Scripture. The authority of the Fathers indeed is at present very low; but should they be allowed to be as fanciful divines and as bad critics as their worst enemies are pleased to represent them, this would detract nothing from their evidence when they bear witness to the constitution of the church in their own times; for of their honesty there can be no doubt; and what the Episcopalian wants of them is only their testimony to matters of fact which fell under the cognizance of their own senses, and about which therefore they could not be deceived. It is here indeed chiefly that he triumphs over his antagonists. In the second and third centuries there was no general council, nor any Christian sovereign. A prelacy therefore, he urges, could not have been *universally* introduced, during that period, either by a concert among the clergy, or by the authority of the civil magistrate.

That at the close of the first or apostolic century the whole Christian world was *Presbyterian*, and that, as we know to have been the case, at the close of the second it was entirely *Episcopal;* that of the cause or progress of the change not a word should be mentioned by the contemporary writers; that whilst Episcopacy was a foul usurpation of the rights of Christ's flock, every Christian writer from Clement downwards should speak of it as a most excellent and even divine institution; that no single presbyter throughout the world should, as far as we know, have said a single word in defence of his insulted order; all this, the Episcopalian maintains, is so utterly improbable as to justify his regarding it as a fable, and one not very cunningly devised.

The candid Episcopalian, however, allows, that in the apostolic age there may have been some churches which at first had only bishops and deacons to perform the offices of religion; for when the number of disciples in any place was so small that they could all meet in one assembly, there was no necessity for any other order of ministers; but it appears that, from the very beginning, *bishops*, *presbyters*, and *deacons* were settled in all the *larger* cities of the Roman empire; and it was in those days an allowed maxim, that without a *bishop* there could be *no church*. The better to understand the original state and institution of episcopacy, it is necessary to observe, that the empire, which contained almost all the known part of the Christian world, was divided originally into provinces of two kinds, the one called *consular*, the other *prætorian*, of which the former were either larger, or of more political importance. In the reign of Augustus the consular provinces were placed under the direct control of the emperor, and were administered by *legates* generally of consular rank; whilst the prætorian were left under the control of the senate and people, and were governed by a *proconsul*, as Asia was. (See Acts, xix. 38.) There was still a third class of smaller provinces retained by the emperor, and governed in general by men of equestrian or even inferior rank, under the title of *procurators;* of these Judæa was one. A province comprehended the cities of a whole region; and in the age of the apostles each city was under the immediate government of certain magistrates within its own body, known by the name of βουλη, or *senatus*, *ordo*, and *curia*, the states and court of the city. Those magistrates were subordinate to the *prætor* or *proconsul;* but among them there was *one* superior to the rest, called sometimes *dictator* and sometimes *defensor civitatis*, whose jurisdiction extended not only over the city itself, but likewise over all the adjacent territory. That territory was denominated προαστεια, or the suburbs, and often reached to the distance of ten or twelve miles round the city, and sometimes much farther, containing within it many villages and small towns under the government of the city magistrates. From some passages in the New Testament, and from the concurring evidence of the earliest writers of the church, it appears to have been the purpose of the apostles to settle a bishop in every city where there was a civil magistracy; but as they could not be personally present in all places at once, it was natural for them to enter upon the great work of converting the nations by first preaching the gospel in that city of each province which was the ordinary residence of the governor; because to it there must have been the greatest resort of people, who would carry the glad tidings with them into the country when they returned. Accordingly, having dispersed themselves over the empire, and made numbers of proselytes in the principal cities, they fixed in each, where they saw it necessary, a *bishop*, with a college of *presbyters* and *deacons*, and gave to those bishops, who were at first called *apostles*, a commission, as the *other* cities of the province should be converted, to fix bishops in them also.

In some of the smaller cities, it is extremely probable that a bishop and a deacon were for a short time the only ecclesiastical officers, till the number of Christians increased so much as to make it impossible for them all to assemble in one house for the purposes of public worship. The bishop then ordained *presbyters* to officiate in those congregations where he himself could not be present, and to assist him in other parts of his pastoral office; but in all their ministrations the presbyters were subordinate to him, who was the chief pastor within the city, who composed the prayers which were offered up in public, and to whom all the other ministers of religion were accountable for their conduct. As long as the number of the faithful was confined within the *walls* of the city, it appears that the bishop with his presbyters and deacons lived together as in a college; that divine service was every Lord's day, or oftener, performed in what was afterwards called the cathedral or mother-church, by the bishop himself, assisted by some of his clergy; and that the congregations which met in other churches, having no *fixed* pastors, were supplied by such presbyters as the bishop chose to send to them from his own church. Whilst matters continued in this state, the clergy had no other revenues than what arose from the voluntary oblations of the people; which were indeed so large as not only to support them with decency, but likewise to answer other ends of charity and munificence. They were commonly divided into four equal parts; of which one was allotted to the bishop, a second to the inferior clergy, a third to the poor, and a fourth to keep the churches in repair; and it was considered as a part of the bishop's duty to take care that the offerings should be faithfully applied to these purposes.

When converts increased in number, and churches were built in the suburbs, each of these churches had a fixed pastor similar to a parish-priest amongst us; but still those pastors, as well as the city clergy, ministered in subordination to the bishop, whose authority extended as far as the civil authority of the Roman magistrate, within which district or diocese it was supreme over all orders of Christians. This every man knows who is acquainted with ecclesiastical history; for the bishop alone could ordain *priests* and *deacons*, administer the rite of *confirmation*, *absolve penitents* who were under church censure, and *exclude from communion* heretics and notorious offenders; and from his sentence there lay no appeal but to a synod of comprovincial bishops.

Such synods were in each province convened by the bishop of the chief city: for the apostles having been careful to place in those cities men of the most eminent gifts and abilities, the other bishops of the provinces applied to them for advice upon every emergency, and paid a particular deference to them upon every occasion. So that though all bishops were of equal authority *as bishops*, yet when they met to consecrate a new bishop, or to deliberate upon the affairs of the church, they yielded a precedency to the bishop of the metropolis, who called them together, and who sat as *president* or *moderator* of the synod. Hence the origin of metropolitans or *archbishops*, whose authority was so considerable, that though there is not a doubt but the *election* of bishops was anciently placed in the clergy and people of the vacant diocese, yet the bishop *elect* could not be *consecrated* without the consent of the archbishop of the province.

In consequence of the very extensive powers with which the primitive bishops were vested, they are commonly styled in the writings of those times *presidents, provosts*, or *inspectors* of the church, *chief priests, princes of the clergy*, and even *princes of the people;* but their authority was wholly spiritual. Those prelates, imitating the example of their Divine Master when on earth, neither possessed nor assumed to themselves any jurisdiction over the *properties* or *civil rights* of men. In consequence of St Paul's having reprimanded the Corinthians for going to law before the *unbelievers*, they were indeed often chosen as *arbiters* of such civil disputes as arose between individuals under their episcopal government; but on these occasions they could not act unless the submission was *voluntarily* made by *both* the contending parties, and *then* their decision was final. When the empire became Christian, this privilege was confirmed to them by law; for any *civil* cause depending before a court of justice could be withdrawn, and by the mutual consent of parties be submitted to the arbitration of the bishop, whose award, which in former times could be enforced only by the terror of church censures, was then enforced by the secular magistrate. In *criminal* causes, where the trial might be for life or death, they were prohibited, both by the canons of the church and by the laws of the state, from acting as judges; and therefore they never suffered such causes to come before them, excepting when it was necessary that the person accused, if found guilty, should be excluded the communion of the faithful.

Be this as it may, it is certain that, through the liberality of the Christian emperors, the bishops enjoyed large revenues and many valuable privileges; but it does not appear that they had any rank or authority, as *barons* or *temporal princes*, till the Gothic nations, which subverted the Roman empire, had embraced the Christian faith. As Christianity incapacitated the leaders of those tribes from officiating as chief priests at the religious rites which were usually celebrated at the opening of their public assemblies, the bishops came naturally to discharge that duty on such occasions, when they must have shared in the rank by sharing in the functions of the chief. The situation in which they thus appeared at the opening of all political conventions, enabled them to join with much effect in the deliberations which ensued; and their superior knowledge, their sacred character, and their influence with the people, soon acquired them power equal to their rank. They must therefore have been thought entitled to obtain admission into that council which was formed by the king and the lay-chiefs at the national assemblies; and as they balanced the authority of those chiefs, we cannot doubt of the king's disposition to give the utmost effect to their claim. Accordingly, we find the dignified clergy, who received large grants of land to be held on the same tenures with the lands of the lay magistrates, presiding along with those magistrates in the provincial assemblies of every degree in all the Gothic nations, and enjoying every advantage of rank and authority in their national diets. Hence the bishop of Rome, and several bishops in Germany, have, like the dukes and marquises of that empire, been for a long time sovereign princes; and hence too the bishops of England and Ireland have always sat, and have an equal right with the lay-peers to sit, in the upper house of parliament. It is however obvious, that, as far as episcopacy is of *apostolical* institution, those peers and princes possess not the *original* character in any higher degree than the bishops in America, who are merely on a footing of equality with other citizens, or those of Scotland, who are little more than the ministers of a small body of dissenters from an established church.

Having thus traced what we may call the progress of episcopacy from the simple purity of apostolic times up to the gorgeous prelacy of the middle ages, it seems proper, before concluding, that we should briefly allude to the history and present state of episcopacy in Scotland.

About the time of the Reformation, the want of order and decency in the worship of the reformed church was abolished in the reign of James VI. by the establishment of episcopacy on very liberal principles. This mode of worship obtained the sanction of the most respectable part of the nation, and continued to flourish under the auspices of government, till it was overthrown by the adherents to the *national covenant*. Its restoration was, however, effected in the year 1662, and twenty-seven years subsequently it was again abolished by the supporters of the Prince of Orange, afterwards William III.

It may be proper to observe, that the Scotch Episcopal Church had no public liturgy during her legal establishment. It is indeed true that the English book of common prayer was used by the first reformers, and there is reason to believe that John Knox himself was by no means inimical to fixed forms of prayer, nor to clerical subordination; but his successor, Andrew Melvil, introduced an equality among the clergy, and excited the minds of the people against the liturgy to such a degree, that an attempt to modify the prayer-book for the use of the Church of Scotland was productive of the solemn league and covenant, and the subsequent ruin of Charles I.

During the reign of William III. the episcopalians were treated with some degree of severity, because they could not transfer to him that allegiance which they had sworn to King James. It is said that they were prohibited from officiating on the Sabbath-day, except " in their own hired houses, where they received such friends as chose to come in unto them." In this manner was their worship conducted, praying either extempore, or from premeditation, till the accession of Queen Anne, when the English liturgy was introduced by degrees into Scotland, under the sanction of an act of parliament, passed on the third of March 1712, " to prevent the disturbing of those of the episcopal communion in that part of Great Britain called Scotland, in the exercise of their religious worship, and in the use of the liturgy of the Church of England." But as their attachment to the house of Stuart was well known, they were, at the rebellion in 1715, laid under some restraints, yet neither severe in their nature, nor of any long continuance, since in 1720 their places of worship were as numerous as before, and frequented by numbers both of rank and respectability, many of whom held places under government.

In England Dr Sancroft, archbishop of Canterbury, with five other bishops, were deprived of their sees for refusing their allegiance to King William; a circumstance which occasioned a schism in the church, as they were extremely popular. Different opinions were entertained respecting the nature and design of the Lord's Supper, and the controversy infected the Episcopalians of Scotland. On the death of Dr Rose, the proscribed bishop of Edinburgh, the diocesan form of church government was opposed by such of the presbyters as had been raised to the episcopal dignity, and it was proposed to govern the whole church by a college of bishops. This plan, for the adoption of which no precedent could be found in the annals of history, was successfully opposed by many of the most enlightened bishops, and it was of consequence abandoned.

After the rebellion of 1745 additional acts of considerable severity were passed against the Scottish episcopalians, the worst effect of which was the formation of many congregations using the English liturgy, and imagining themselves episcopalians, whilst they and their ministers were living in separation from the bishops of the country. All restraints upon Scottish episcopalians were, however, removed by the act of 1792; since which period they have enjoyed full liberty of conscience, in common with other dissenters from the established church.

The repeal of the penal acts of course tended to unite the independent chapels above mentioned to the episcopal church; but an impediment still existed, which delayed the progress of this union for several years. The Scottish Episcopal Church had never yet adopted the English Confession of Faith; and though the act of 1792 required that every tolerated episcopalian minister should sign the *Thirty-nine Articles*, still, as might have been expected, those ministers were not prepared immediately to sign a declaration of faith at a secular mandate. There consequently remained an ostensible reason for separation till the year 1804, when a convocation of the episcopal church declared their readiness to sign the Thirty-nine Articles of the Church of England, in the manner enacted by the act of 1792.

The cause of separation being thus removed, the English chapels began immediately to unite themselves to the Scottish Episcopal Church, and to submit to the authority of the bishop within whose jurisdiction they lay; and at the present moment (1834) there are but three congregations in Scotland using the English liturgy, who refuse obedience to the Scottish bishops. The episcopal church in Scotland is now governed by six bishops, having under them about seventy presbyters entrusted with the cure of souls.

EPISCOPAL, something belonging to Bishops.

EPISCOPALIANS, in *Ecclesiastical History*, an appellation given to those who prefer the episcopal government and discipline to all others.

EPISCOPIUS, Simon, one of the most learned men of the seventeenth century, and the chief supporter of the Arminian sect, was born at Amsterdam in 1583. In 1612 he was chosen divinity professor at Leyden, in the room of Gomarus, who resigned; but the functions of his office, with his private studies, were light, compared with the difficulties he sustained on account of the Arminian controversy. The states of Holland having invited Episcopius to take his place at the synod of Dort, he went thither, accompanied by some ministers; but the synod would not allow them to sit as judges, nor to appear in any other capacity than as persons summoned before them; and, in the end, they were deposed from their functions and banished. Episcopius and his persecuted brethren retired to Antwerp; but the times growing more favourable, he returned to Holland in 1626, and was made minister of the church of the Remonstrants at Rotterdam. In 1634 he was chosen rector of the college founded by the sect at Amsterdam, and died in 1643. His works form two volumes in folio.

EPISODE, in *Poetry*, a separate incident, story, or action, which a poet invents and connects with his principal action, so that his work may abound with a greater diversity of events. See Poetry.

EPISTEMONARCH, in the ancient Greek church, an officer of great dignity, who, acting in the capacity of censor, had the care of every thing relating to faith.

EPISTLE, the same as letter; but it is now chiefly used in speaking of ancient writings, as the epistles of St Paul, of Cicero, of Pliny, and so on.

Epistles and Gospels, in the liturgy of the Church of England, are portions of Scripture selected from the writings of the evangelists and apostles, and appointed to be read, in the communion service, on Sundays and holidays. They are believed to have been selected by St Jerome, and by him put into the lectionary.

The epistles and gospels are placed in an admirable order and method, and bear a special relation to the several days on which they are read. The year is distinguished into two parts; the first being designed to commemorate Christ's sojourn upon earth, and the other to instruct us to live after his example. The former includes the whole time from Advent to Trinity Sunday; the latter all the Sundays from Trinity to Advent.

EPISTYLE, in the ancient architecture, a term used by the Greeks for what we call *architrave*, that is, a massive piece of stone or wood laid immediately over the capital of a column.

EPITAPH (from επι, *upon*, and ταφος, *sepulchre*), a monumental inscription in honour or in memory of a person deceased. It has been disputed whether the ancient Jews inscribed epitaphs on the monuments of the dead; but however this may be, it is certain that epitaphs of very ancient date are found among them. The Athenians, by way of epitaph, commonly put only the name of the dead, with the epithet χρηστος, signifying *good*, or ἡρως, *hero*, and the word χαιρε, intimating their good wishes; but the name of the deceased's father and that of his tribe were occasionally added. The Lacedæmonians allowed epitaphs to none but those who had died in battle. The Romans inscribed their epitaphs *diis manibus;* and frequently introduced the dead, by way of prosopopœia, speaking to the living.

EPITHALAMIUM, in *Poetry*, a nuptial song or composition in praise of the bride and bridegroom, and praying for their prosperity.

Epithalamia were sung amongst the Jews at the door of the bride, by her friends and companions, the evening before the marriage. Amongst the Greeks the epithalamium was sung as soon as the married couple had gone to bed, and was attended with shouts and stamping of the feet to drown the cries of the bride. They returned in the morning, and with the same song, a little altered, saluted them again. The evening song was called επιθαλαμια κοιμητικα, the morning salute was called επιθαλαμια εγερτικα. The practice amongst the Romans was the same, but their epithalamia were often obscene.

EPITHET, in *Poetry* and *Rhetoric*, an adjective expressing some quality of a substantive to which it is joined, or such an adjective as is annexed to substantives by way of ornament and illustration, not to make up an essential part of the description.

EPITOME, in literary history, the same with ABRIDGMENT.

EPITRITUS, in *Prosody*, a foot consisting of three long syllables and one short. Of these, grammarians reckon four kinds; the first consisting of an iambus and spondee, as *sălūtāntēs;* the second, of a trocheus and spondee, as *cōncĭtātī;* the third of a spondee and an iambus, as *cōmmūnĭcāns;* and the fourth of a spondee and trocheus, as *īncāntārĕ*. See the articles SPONDEUS, TROCHEUS, and IAMBUS.

EPITROPUS, a kind of judge, or rather an arbitrator, which the Greek Christians, under the dominion of the Turks, were in use to elect in the several cities, in order to terminate the differences that arose among them, and thus avoid carrying them before the Turkish magistrates. See ARBITRATOR.

EPOCHA, in *Chronology*, a term or fixed point of time whence the succeeding years are numbered or reckoned.

EPODE, in *Lyric Poetry*, the third or last part of the ode, the ancient ode being divided into strophe, antistrophe, and epode. The epode was sung by the priests, standing still before the altar, after all the turns and returns of the strophe and antistrophe, and was not confined to any precise number or kind of verses. The epode is now a general name for all kinds of little verses which follow one or more great ones, of what kind soever these be; and in this sense a pentameter is an epode after an hexameter.

EPOPŒIA, in *Poetry*, the history, action, or fable, which forms the subject of an epic poem. The word is derived from the Greek επος, *carmen*, verse, and ποιεω, *facio*, I make. In the common use of the word, however, *epopœia* is the same with *epos*, or epic poem itself. See POETRY.

EPPING, a market-town of the county of Essex, in the hundred of Waltham, seventeen miles from London. It was remarkable for its situation in a district formerly very woody, and preserved by our ancient monarchs for the enjoyment of the sports of the field. It was then called Waltham Forest, and extended almost to the capital. In the same neighbourhood also was Hainault Forest, where a fair was held for many centuries under a remarkable tree, well known by the name of Fairlop Oak, which has existed till recently, and was of prodigious size. The greater part of these districts have been disforested, and converted into fertile fields. The town of Epping has a market, which is held on Friday, but at a small distance from the buildings. It preserves the fame it has long enjoyed for its butter, its sausages, and its pork, in the London markets. The population amounted in 1801 to 1729, in 1811 to 1874, in 1821 to 2146, and in 1831 to 2313.

EPPINGEN, a city, the capital of a bailiwick of the same name, in the grand duchy of Baden in Germany. It is situated on the river Elsenz, and contains 336 houses, with 2439 inhabitants.

EPSOM, a town of the county of Surrey, fifteen miles from London. It was formerly frequented on account of its saline springs, and is now so on account of the races held on the down near it. County meetings are generally held here. The neighbourhood abounds with elegant seats of the nobility and gentry. The population amounted in 1801 to 2404, in 1811 to 2515, in 1821 to 2890, and in 1831 to 3231.

EPULARES, in *Antiquity*, an epithet given to those who were admitted to the sacred *epulæ* or entertainments, it being unlawful for any to be present at them who were not pure and chaste.

EPULO, in *Antiquity*, the name of a minister of sacrifice among the Romans.

The pontifices not being able to attend all the sacrifices performed at Rome to the numerous gods adored by that people, appointed three ministers, whom they called *epulones*, because they had conferred on them the care and management of the *epula*, or feasts in the solemn games and festivals. Their number was at length augmented from three to seven, and afterwards to ten. Their first establishment was in the year of Rome 558, under the consulate of L. Furius Purpureo and M. Claudius Marcellus.

EPULUM, in *Antiquity*, a solemn feast prepared for the gods in times of public danger. The feast was sumptuous, and the gods being formally invited, attended by proxy; for the statues were brought on rich beds furnished with soft pillows, called *pulvinaria;* and thus accommodated, their godships were placed on their couches at the most honourable part of the table. The care of the *epula* belonged to the *epulones*, and the gods were plentifully served with the richest dainties, as if they were able to eat; but the *epulones* performed that function for the divinities, and no doubt showed themselves competent proxies.

EPULUM is also used to signify any solemn feast; and hence we meet with *epulum ferale*, a funeral entertainment.

EQUABLE, an appellation given to such motions as always continue the same, without being either accelerated or retarded.

EQUAL, a term of relation between two or more things of the same magnitude, quantity, or quality. Mathematicians speak of *equal* lines, angles, figures, circles, ratios, solids.

EQUALITY is that agreement between two or more things, by which they are denominated equal.

EQUANIMITY denotes that calm and even frame of mind and temper, under good or bad fortune, by which a man appears to be neither puffed up nor overjoyed with prosperity, nor dispirited, soured, or rendered uneasy by adversity.

EQUATIONS.

1. In all the applications of algebra, it is not the magnitudes concerned that we immediately consider, but merely their proportions. In every class of quantities of the same kind, one being adopted as the unit of comparison, all the rest are referred to this standard, and are represented by the proportions they bear to it. The letters of the alphabet, or other symbols, used in algebra, are not, therefore, properly speaking, the representatives of magnitudes; they denote ratios, or abstract numbers, viewed, as in the fifth book of Euclid, in the most general manner, and independently of any particular system of arithmetic or numeration.

The ancient geometry follows a different procedure. In that science the attention is in every case confined to the magnitudes under actual consideration. A general property of triangles is established, by showing that it is true of any particular triangle that comes under the proposed hypothesis. The geometer contemplates particular instances, presenting for the most part relations not very complex, and easily kept in view. On this account he carries on his investigations with the greatest clearness, and is in no danger of falling into contradiction or paradox. But his science is little susceptible of general methods. If any process within the compass of the ancient geometry be entitled to that appellation, it is what is called the method of exhaustion. Every geometer perceives that all the demonstrations under this head have the closest analogy. Yet, after a hundred applications, it is still necessary, in any new case, to pursue the reasoning through all its details, without deriving assistance from any general conclusion previously obtained.

Algebra possesses a great advantage over geometry in generalizing its processes. Problems relating to magnitudes of the most different kinds, nevertheless, lead to similar expressions in numbers. Questions in geometry, in mechanics, or concerning mercantile business, are made to depend on the same rules for their solution. It may be said that algebra and the modern analysis accomplish, for all the mathematical sciences, the project, entertained by some ingenious men, of an universal and philosophical language, which, being founded on an exact scrutiny into the nature of things, and on what they possess in common, might greatly facilitate the acquisition and the extension of our knowledge.

The spirit of generalization peculiar to algebra is nowhere more conspicuous than in the doctrine of equations. Every determinate problem that can occupy the attention of the mathematician, is ultimately reduced to the finding of such numbers as are necessary to determine the unknown quantity or quantities, by means of the equations that subsist between those numbers, and others which are given in the question. A wide field of mathematical investigation is thus brought under a limited number of algebraic expressions.

In treating of equations, it will not be necessary to begin with laying down a formal definition. We confine ourselves, in this article, to the consideration of such equations as contain only one unknown quantity. We further suppose that the elementary operations preparatory to solution are already performed; so that the unknown quantity is clear of radical signs, and is nowhere found in the denominator of a fraction; likewise that all the separate terms are brought to one side of the sign of equality, and arranged in such a manner that the first term, which must always be positive, and have unit for its index, contains the highest power of the unknown quantity, or x; the second term contains the next highest power, and so on, the term which does not contain x being placed last. This arrangement must always be understood when any term is distinguished by the order it stands in; but it will sometimes be convenient to write the terms in an inverted order, arranging them according to the indices of the unknown quantity.

Equations are divided into different classes or orders, according to the highest power of the unknown quantity found in their terms.

An equation of the first degree, or a simple equation, is one which contains x only, without any of its powers, as $x - \mathrm{A} = 0$.

A quadratic equation, or one of the second degree, contains the square of x, as $x^2 - \mathrm{A} = 0$, or $x^2 - \mathrm{A}x + \mathrm{B} = 0$.

A cubic equation, or one of the third degree, contains the cube, or third power of x, as $x^3 - \mathrm{A} = 0$, or $x^3 - \mathrm{A}x^2 + \mathrm{B}x - \mathrm{C} = 0$.

A biquadratic equation, or one of the fourth degree, contains the fourth power, or biquadrate of x, as $x^4 - \mathrm{A} = 0$, or $x^4 - \mathrm{A}x^3 + \mathrm{B}x^2 - \mathrm{C}x + \mathrm{D} = 0$.

And, in general, an equation of the n^{th} degree contains the n^{th} power of x, and the powers inferior to the n^{th}, such as

$$x^n - \mathrm{A}x^{n-1} + \mathrm{B}x^{n-2} \ldots\ldots\ldots\ldots - \mathrm{M}x + \mathrm{N} = 0.$$

A root of an equation is a value of the unknown number x. Thus, if a represent a number, and if its powers, a, a^2, a^3, when they are substituted in the equation for x, x^2, x^3, &c. produce an equality between the positive and negative terms, then a is a root of the equation, and it is a positive root; but if, for x, x^2, x^3, &c. we must substitute $-a$, a^2, $-a^3$, &c. which are the powers of $-a$, in order to obtain the like equality, then a is a negative root of the equation.

What we have here called roots are more generally named *real roots*, to distinguish them from those expressions to which the appellation of *imaginary or impossible roots* has been given. As it will conduce to perspicuity, we shall always use the word root in the sense here defined, unless when imaginary or impossible roots are expressly mentioned.

From the definitions laid down, it follows that the negative roots of the equation,

$$0 = \mathrm{N} + \mathrm{M}x + \mathrm{L}x^2 + \mathrm{K}x^3 +, \&c.$$

are the same with the positive roots of the equation,

$$0 = \mathrm{N} - \mathrm{M}x + \mathrm{L}x^2 - \mathrm{K}x^3 +, \&c.$$

in which the signs only of all the terms containing the odd powers of x are changed. For the same result is obtained, whether we make x equal to $-a$ in the first equation, or to $+a$ in the second.

2. A great advantage has resulted from the practice introduced by Harriot, of writing all the terms of an equation on one side of the sign of equality. The polynomes formed by all the terms thus brought together are rational and integral functions of the unknown quantity; and the question is, to find in what circumstances such expressions are equal to zero. The most likely way of succeeding in this research, is to resolve the functions into their most simple component factors. Harriot supposed that every rational function can be produced by the continued multiplication of binomial factors, and in

this he has been followed by succeeding algebraists. The modern theory of equations is entirely founded on this supposition, which, although it has not been demonstrated, has yet, in some measure, been verified in the progress of the science, and by the admission of those artificial expressions called imaginary or impossible quantities. But there is a distinction between the real and impossible binomial factors of a rational polynome; for the first are expressions complete and significant by themselves, without reference to other quantities; whereas one impossible factor necessarily supposes the existence of another, the two related expressions being such that their multiplication produces one real factor of the second degree. Thus, every pair of impossible factors is equivalent to a real quadratic factor; and, by an unavoidable consequence of the forced supposition made by Harriot, the attention of algebraists has been drawn to the two impossible expressions, instead of the real one which they compose. In order to place the doctrine of equations and the theory of impossible roots on a solid foundation, it appears necessary to attempt the resolution of rational functions into their component factors by a rigorous analysis, free from arbitrary suppositions.

To resolve the rational function $f(x)$ into its component factors, we must begin with inquiring whether it can be divided without a remainder, by a division such as $x-a$, or $x+a$. If it can, the proposed function will be equal to $(x \mp a) \times f'(x)$, where $f'(x)$, the quotient of the division, is a function similar to $f(x)$, but of an order one degree lower. In like manner, it may be possible to reduce $f'(x)$ to a degree still lower, by means of one or more divisors of the same form; and, in certain cases, the first function may be entirely exhausted by successive binomial divisors. When this happens, the divisors $x-a$, $x-b$, $x-c$, &c. will be equal in number to the exponent of the highest power of x, and their continued product will be equal to $f(x)$. It is evident, that by multiplying together a proper number of such factors, an algebraic expression may be formed similar to any rational and integral function, and the co-efficients of this product will likewise contain as many quantities to be determined at pleasure as there are co-efficients in the given function. But we should reason badly if, from this process of composition, we should infer that a product arising from the multiplication of a certain number of simple factors may have any given co-efficients, or will coincide with any proposed polynome of the same degree. This is a point that can be ascertained only by a process of analysis or resolution, and by seeking all the binomial divisors any given function admits of. In fact, the cases are extremely rare in which an algebraic function can be completely exhausted by real binomial divisors. There are many polynomes which have not a single divisor of this kind; and, in the progress of resolution, we generally arrive at a function which cannot be further divided. When this is the case, it must be tried whether a quadratic divisor, as x^2+mx+n, will not be successful in lowering the function. But here it must be observed that such divisors are of two kinds; one, as $(x-\varrho)^2-\tau^2$, which can be resolved into two binomial factors; and one, as $(x-\varrho)^2+\tau^2$, which cannot be so resolved without introducing imaginary or impossible expressions. Now, to divide by a divisor of the first kind is the same thing as to divide by the two binomial factors of which it is composed; and, therefore, it is the second kind of quadratic factors only that need be tried, or that can succeed, in lowering a function already deprived of all its simple divisors. After quadratic divisors, those of the third degree would naturally come to be considered; but this is unnecessary, because algebraists have found that every rational function may be completely exhausted by simple and quadratic factors.

What has now been said naturally distributes the subject under two heads; one treating of the simple or binomial factors, and the other of the quadratic or trinomial factors, of algebraic equations.

Binomial Factors.

3. The first object of inquiry must be to find the conditions necessary, in order that a binomial quantity, as $x-a$, or $x+a$, shall divide a rational polynome without a remainder. Suppose that $x-a$ is a divisor of the polynome,

$$x^n + Ax^{n-1} + Bx^{n-2} \ldots\ldots\ldots\ldots + Mx + N,$$

which we shall denote by $f(x)$: then we shall have

$$f(x) = N + Mx + Lx^2 + Kx^3 +, \&c.$$
$$f(a) = N + Ma + La^2 + Ka^3 +, \&c.$$

wherefore, by subtracting and dividing by $x-a$, we get

$$\frac{f(x)}{x-a} - \frac{f(a)}{x-a} = M\frac{x-a}{x-a} + L\frac{x^2-a^2}{x-a} + K\frac{x^3-a^3}{x-a} +, \&c.$$

Now, it is known that the difference between any like powers of two numbers is exactly divisible by the difference of those numbers: hence all the quantities on the right-hand side of the sign of equality form an integral expression. But as $f(a)$ does not contain x, it cannot be divisible by $x-a$; it follows, therefore, that $f(x)$ cannot be divisible by $x-a$, unless $f(a)=0$; and it is obvious that this condition is the only one necessary. Thus, the polynome $f(x)$ will be divisible by $x-a$ when a is a positive root of the equation $f(x)=0$, otherwise not.

Again, let the divisor be $x+a$; then,

$$f(x) = N + Mx + Lx^2 + Kx^3 +, \&c.$$
$$f(-a) = N - Ma + La^2 - Ka^3 +, \&c.$$

and by proceeding as before,

$$\frac{f(x)}{x+a} - \frac{f(-a)}{x+a} = M \cdot \frac{x+a}{x+a} + L\frac{x^2-a^2}{x+a} + K \cdot \frac{x^3+a^3}{x+a} +, \&c.$$

Here again all the divisions on the right-hand side of the sign of equality can be exactly performed; and we must, therefore, conclude that $f(x)$ will be divisible by $x+a$ only when $f(-a)=0$, that is, when a is a negative root of the equation $f(x)=0$.

Now $x \mp a$ being a divisor of $f(x)$, the quotient, which we may denote by $f'(x)$, will be a polynome of $(n-1)$ dimensions, or one degree lower than $f(x)$; and we shall have

$$f(x) = (x \mp a) \times f'(x).$$

From this equation it appears that every value of x that makes $f'(x)$ equal to zero, will likewise make $f(x)$ equal to zero; consequently every binomial divisor of the first function will likewise be a divisor of the second. And if $f'(x)$ has no roots, and no binomial divisors, neither will $f(x)$ have any roots except $\pm a$, nor any binomial divisors except $x \mp a$. Suppose that the polynomes $f(x)$ and $f'(x)$ have the common root $\pm b$; they will likewise have the common divisor $x \mp b$; and if we put $f''(x)$ for the quotient arising from the division of $f'(x)$ by $x \mp b$, so that $f'(x) = (x \mp b) \cdot f''(x)$, we shall have

$$f(x) = (x \mp a) \cdot (x \mp b) \cdot f''(x),$$

in which equation $f''(x)$ is a polynome of $n-2$ dimensions, or two degrees lower than $f(x)$.

It is evident we may continue to reason in the same manner either till, after successive divisions, we come at last to a binomial quotient, in which case the original polynome $f(x)$ will be completely resolved into binomial factors; or till we come to a quotient that has no roots, in which case $f(x)$ will have no binomial factors except those previously found. We may therefore conclude that "a rational polynome has as many binomial factors as it has roots, and no more; every positive root producing a factor of the form $x-a$, and every negative root one of the form $x+a$; and since the number of binomial factors can never be greater than the dimensions of the polynome, its roots cannot exceed the same number."

4. There are very few cases in which it can be known immediately and by inspection that an equation has one or more roots. These cases depend upon the following propositions, viz. "If $\varphi(x)$ denote a rational polynome, having x, or some integral power of x, in every one of its terms, and likewise having the term that contains the greatest power of x positive, a value of x may be found that will make $\varphi(x)$ equal to any positive quantity, as s."

Suppose, first, that all the terms of $\varphi(x)$ are positive; then x^n being the first term, or that in which x rises to the highest power, if $s=t^n$, and $\lambda > t$, it is manifest that

$$\varphi(\lambda) > t^n > s.$$

Therefore, while x increases from 0 to be equal to λ, the function $\varphi(x)$ increases from 0 to be greater than s; and as the variations of $\varphi(x)$, however irregular they may be, are connected by the law of continuity, the function will pass through every gradation of magnitude between 0 and the greatest limit $\varphi(\lambda)$. Consequently, there is a value of x between 0 and λ, that will make $\varphi(x)$ equal to s.

When the terms of $\varphi(x)$ are not all positive, let all the positive terms except x^n be rejected, and all the negative terms be retained, and we shall have $\varphi(x)$ equal to, or greater than,

$$x^n - Fx^{n-i-1} - Hx^{n-i'-1} -, \&c.$$

But, s being equal to t^n, we have

$$t^n = x^n - (x-t) . \left\{ x^{n-1} + tx^{n-2} + t^2 x^{n-3} \ldots + t^{n-1} \right\}$$

Now, by equating the negative terms of the first expression to the terms containing the like powers of x in the value of t^n, we shall get

$$(x-t) . t^i = F, \quad (x-t) . t^{i'} = H, \&c.$$

And hence,

$$x = t + \frac{F}{t^i}, \quad x = t + \frac{H}{t^{i'}}, \&c.$$

Let λ be either equal to or exceed the greatest of those values of x, then we shall have

$$\varphi(\lambda) > t^n > s.$$

Wherefore, as before, there is a value of x between 0 and λ, that will make $\varphi(x)$ equal to s.

From what has now been proved, we derive the following properties of equations.

1. "Every equation of odd dimensions has at least one positive root when the last term is negative, and one negative root when the last term is positive."

If the last term be negative, as in this instance,

$$x^{2n+1} + Ax^{2n} + Bx^{2n-1} \ldots + Mx - N = 0;$$

according to what has been proved, a value of x, viz. a, may be found that will satisfy the condition,

$$a^{2n+1} + Aa^{2n} + Ba^{2n-1} \ldots + Ma = N;$$

then a is a positive root of the equation.

When the last term is positive, as in this equation,

$$x^{2n+1} + Ax^{2n} + Bx^{2n-1} \ldots + Mx + N = 0,$$

change the sign of the last term, and the signs of all the terms that contain the even powers of x, then the polynome will become

$$x^{2n+1} - Ax^{2n} + Bx^{2n-1} \ldots + Mx - N:$$

and a value of x, viz. a, may be found such that

$$a^{2n+1} - Aa^{2n} + Ba^{2n-1} \ldots + Ma = N.$$

Now transpose N, and then change the signs of all the terms, and we shall get

$$-a^{2n+1} + Aa^{2n} - Ba^{2n-1} \ldots - Ma + N = 0,$$

which shows that a is a negative root of the equation.

2. "Every equation of even dimensions having its last term negative, has two roots, one positive and one negative."

Let the equation be

$$x^{2n} + Ax^{2n-1} + Bx^{2n-2} \ldots + Mx - N = 0;$$

and consider the polynomes,

$$x^{2n} + Ax^{2n-1} + Bx^{2n-2} \ldots + Mx - N,$$
$$x^{2n} - Ax^{2n-1} + Bx^{2n-2} \ldots - Mx - N,$$

in the latter of which the signs of all the terms containing the odd powers of x are changed; then there are two values of x, viz. a and b, such as to answer the conditions,

$$a^{2n} + Aa^{2n-1} \ldots + Ma = N$$
$$b^{2n} - Ab^{2n-1} \ldots - Mb = N:$$

consequently a is a positive and b a negative root of the equation.

3. "A polynome of even dimensions, which has no binomial factors, is always positive, whatever value be substituted for the unknown quantity."

Let the polynome be $f(x)$ or

$$x^{2n} + Ax^{2n-1} \ldots Mx + N;$$

then the last term, or that term which does not contain x, must be positive; for otherwise the polynome would have two roots and two binomial factors, contrary to the hypothesis. Now, if it be possible, let the polynome have a negative value when λ is substituted for x, so that $f(\lambda) = -P$; therefore, when $x=0$, $f(x)$ is equal to the positive quantity N; and, when $x=\lambda$, the same function is equal to $-P$; but since $f(x)$ passes through all degrees of magnitude between N and $-P$, while x varies from 0 to λ, it will become equal to zero when x has some intermediate value; therefore the polynome has one root between 0 and λ, and one binomial divisor corresponding to that root, contrary to the hypothesis.

It may be observed, that the converse of this proposition is not true; for a polynome of even dimensions, that has such factors as $(x-a)^2$, $(x-a)^4$, $(x-a)^{2m}$, may never become negative, although it is capable of being equal to zero.

5. The properties demonstrated in the last section lead to this general proposition relating to the number of roots in any equation, viz. "In any equation the number of all the roots is even when the dimensions are even, and odd when the dimensions are odd."

For every equation has as many binomial divisors as it has roots; and if we suppose an odd number of roots in an equation of even dimensions, or an even number in one of odd dimensions, the last quotient, after dividing successively by all the divisors, would be a polynome of odd dimensions, having at least one root, which would likewise be a root of the proposed equation. Therefore the number of all the roots of an equation cannot be even when the dimensions are odd, nor odd when the dimensions are even.

And again, since every polynome is equal to the continued product of all its binomial divisors, and the quotient last found, after dividing by them all successively, we obtain the following proposition, viz.: "Every rational polynome is equal either to the continued product of as many binomial factors as it has dimensions; or to the continued product of an even or odd number of such factors, according as the dimensions of the polynome are even or odd, and a polynome of even dimensions, which, having no binomial factors, is always positive, whatever value be substituted for the unknown quantity."

Equal roots.

6. When several of the binomial factors of an equation are equal to one another, it is said to have so many equal roots. In this case the equation can be divided a number of times successively by the same binomial divisor. Thus, an equation which is twice divisible by $x-a$, or, which is the same thing, once by $(x-a)^2$, has two roots equal to a; and if it can be divided by $(x-a)^m$, it has m roots equal to a.

The most obvious way of finding the conditions on which the equality of the roots depends would therefore be to expand the divisor $(x-a)^m$ by the binomial theorem, and then divide the equation by it; for, after the integral quotient is obtained, the required conditions will be found by making the several parts of the remainder separately equal to zero. The number of the conditions found in this manner is equal to the exponent of the divisor; for of so many parts will the remainder of the division consist. But, in a complex operation, it is difficult to ascertain the remainder; and, besides, it is not necessary to consider all the equations obtained by this process, because both the number and the value of the equal roots can be found by means of two of them only.

The inconveniences just mentioned will be avoided by proceeding in the following manner: Let the equation be

$$x^n+Ax^{n-1}+Bx^{n-2}\ldots+Mx+N=0;$$

then, if it be divisible by $(x-a)^m$, the quotient will be a polynome of $n-m$ dimensions; and we may therefore suppose that the expression

$$x^n+Ax^{n-1}+Bx^{n-2}\ldots+Mx+N$$

is equal to the product,

$$(x-a)^m\times\{x^{n-m}+A'x^{n-m-1}+B'x^{n-m-2}+,\text{ \&c.}\}.$$

In these expressions, x may have any value whatever; and therefore the equality between them will still subsist if we substitute $x+i$ for x, i being any arbitrary number; therefore the expression

$$(x+i)^n+A(x+i)^{n-1}+B(x+i)^{n-2}\ldots+M(x+i)+N$$

will be equal to the product

$$(x-a+i)^m\times\{(x+i)^{n-m}+A'(x+i)^{n-m-1}+,\text{ \&c.}\}.$$

Now, let the several powers of $(x+i)$ be expanded by the binomial theorem, and put

$$X=x^n+Ax^{n-1}+Bx^{n-2}\ldots+Mx+N,$$

$$Y=nx^{n-1}+(n-1)Ax^{n-2}+(n-2)Bx^{n-3}\ldots+M,$$

$$Z=n\frac{n-1}{2}x^{n-2}+(n-1)\frac{n-2}{2}Ax^{n-3}+,\text{ \&c.}$$

$$V=n\frac{n-1}{2}\cdot\frac{n-2}{3}x^{n-3}+(n-1)\cdot\frac{n-2}{2}\cdot\frac{n-2}{3}Ax^{n-4}$$

$$+,\text{ \&c.}\qquad\text{\&c.}\qquad\text{\&c.}$$

then the given polynome of n dimensions will become

$$X+Yi+Zi^2+Vi^3+,\text{ \&c.}\qquad\text{(A).}$$

And if the like operations are performed in the polynome of $n-m$ dimensions, and $(x-a+i)^m$ be expanded by the binomial theorem, the product of these two expressions will become

$$\left\{(x-a)^m+m.(x-a)^{m-1}i+m.\frac{m-1}{2}.(x-a)^{m-2}i^2\right.$$

$$\left.+,\text{ \&c.}\right\}\times\left\{X'+Y'i+Z\,i^2+,\text{ \&c.}\right\}.\qquad\text{(B).}$$

The expression (A) being equal to the product (B), whatever i stands for, the co-efficients of the like powers of i must be equal; and hence, by equating the terms in which i is wanting, and likewise the terms that contain the first power of i, we get

$$X=(x-a)^mX'$$

$$Y=(x-a)^mY'+m(x-a)^{m-1}X';$$

which proves that $(x-a)^{m-1}$ is a common divisor of X and Y. If, therefore, by means of the usual process, we seek the greatest common measure of the two polynomes X, Y, or,

$$x^n+Ax^{n-1}+Bx^{n-2}\ldots\ldots+Mx+N,$$

$$nx^{n-1}+(n-1)Ax^{n-2}+(n-2)Bx^{n-2}\ldots+M;$$

we shall obtain the factor $(x-a)^{m-1}$, and the given polynome X will be divisible by $(x-a)^m$; that is, it will contain the common factor $x-a$ once more than the polynome Y contains it.

If we proceed farther, and equate the co-efficients of i^2 in the expressions (A) and (B), we shall get

$$Z=(x-a)^mZ'+m(x-a)^{m-1}Y'$$

$$+m.\frac{m-1}{2}(x-a)^{m-2}X';$$

which shows that Z is divisible by $(x-a)^{m-2}$. In the same manner, it may be proved, that V is divisible by $(x-a)^{m-3}$, and so on. It appears, therefore, that the first m co-efficients of the expression (A) are respectively divisible by $(x-a)^m$, $(x-a)^{m-1}$, $(x-a)^{m-2}$, &c.; and consequently we shall have

$$X=0,\ Y=0,\ Z=0,\ V=0,\text{ \&c.}$$

when the common root a is substituted for x.

If the polynome X is divisible by $\{(x-\alpha^2+\beta^2)\}^n$, it may be proved in like manner that $\{(x-a)^2+\beta^2\}^{n-1}$ will be a common divisor of X and Y.

We may therefore lay down the following rule for finding all the double, triple, &c. divisors of any given polynome X: "Find R, the greatest common measure of X and Y, and resolve it into its elementary factors; then each of these factors will be contained in X once more than in R."

7. If it be required to find how many of the roots of an equation are positive, and how many are negative, we have for this purpose the rule first published in the *Geometry* of Descartes. This celebrated rule seems to have been discovered by induction; at least its author gave no demonstration of it, and disputes arose about its true import. It was demonstrated for the first time by Du Gua, in the *Mémoires de Paris*; but many other demonstrations of it have since appeared, of which that of Segner, in the *Mémoires de Berlin*, 1756, is not only the most simple, but probably the most simple that will ever be invented.

Segner deduced the rule of Descartes from the following analytical proposition, viz.

"If any rational polynome be multiplied by $x-a$, the changes from one sign to another, from + to — 1, and from — to + 1, will be at least one more in the product than in the given polynome; and if it be multiplied by $x+a$, the successions of the same sign, of + to + 1, and of — to — 1, will be at least one more."

Let the proposed polynome be

$$x^n\pm Ax^{n-1}\pm Bx^{n-1}\ldots\ldots\pm Mx\pm N;$$

then, according to the usual process, the product of the polynome by $x-a$ will be found by adding these two lines, viz.

$$\left.\begin{array}{l}x^{n+1}\pm Ax^n\pm Bx^{n-1}\ldots\pm Mx^2\pm Nx\\ \qquad -ax^n\mp Aa^{xn-1}\ldots\quad\mp Lax^2\mp Max\mp Na\end{array}\right\}$$

the signs of the several terms remaining unchanged in the first line, and being all changed in the second line. It is evident, therefore, that the terms of the product will have the same signs with the respective terms of the proposed polynome, except when a co-efficient in the second line is greater than the one above it, and likewise has a contrary sign; the sign of the last term of the product being always the same with the sign of the last term of the second line. Now, beginning on the left hand, pass over the terms of the first line, so long as they have the same signs with the terms of the product. When this ceases to be the case, the signs in the product will be the same as in the second line, and contrary to those in the first line; wherefore descend to the second line, and pass along its terms till the signs in the product are again the same as those in the first line, and then ascend to that line. Continue thus descending and ascending alternately till all the terms in both lines are taken in. At the conclusion, it is evident that the descendings are always one more than the ascendings, because the passing from one line to another both begins and ends with descending.

If we descend from $\pm Ax^n$ in the first line, to $\mp Aax^{n-1}$ in the second line, it is evident that the signs of $\pm Ax^n$ and $\pm Bx^{n-}$ in the first line will be the same, both being contrary to the sign of $\mp Aax^{n-1}$ in the second line. Therefore, in the given polynome, the first and second terms have the same sign. But in the product the like terms have contrary signs; for the second term of the product has the same sign with $\pm Ax^n$ in the first line, and the third term of the product has the same sign with $\mp Aax^{n-1}$ in the second line. Thus it appears that a variation from one sign to another is introduced in the product, instead of a continuation of the same sign that takes place in the given polynome; and the same thing will happen at every descending.

In ascending from the second line to the first, there may either be a continuation of the product instead of a variation in the given polynome, or the contrary; but one of these two must take place.

Now, so long as we keep on the first line, the signs in the product are the same with those of the given polynome; and, so long as we keep on the second line, the signs in the product are contrary to those in the polynome. In both cases, therefore, the variations from + to — 1, and from — to + 1, are the same in the product and in the polynome. Every descending introduces a variation in the product, instead of a continuation that takes place in the polynome; and although it be supposed that every ascending introduces a continuation in the product instead of a variation that exists in the polynome, yet, on the whole, the variations introduced must be one more than the continuations, because the descendings are one more than the ascendings.

Again, if the given polynome be multiplied by $x + a$, the product will be the sum of these two lines, viz.

$$\left.\begin{array}{l} x^{n+1} \pm Ax^n \pm Bx^{n-1} \ldots \pm Mx^2 \pm Nx \\ \qquad + ax^n \pm Aax^{n-1} \qquad \pm Lax^2 \pm Max \pm Na. \end{array}\right\}$$

Here the terms of both lines have the same signs; and, as before, the signs in the product will be the same with the signs of the proposed polynome, unless when a co-efficient in the second line is greater than the one above it, and likewise has a contrary sign; the sign of the last term of the product being always the same with the sign of the last term in the second line. Now, if we pass along all the terms of both lines, descending from the first line to the second, when the signs in the product change from being the same with those in the given polynome, to be contrary to them; and ascending from the second line to the first, when the signs in the product change from being contrary to those in the polynome, to be the same with them; it is evident that the descendings will be one more than the ascendings, as in the former case.

If we descend from $\pm Ax^n$ in the first line, to $\pm Aax^{n-1}$ in the second line, the two terms $\pm Ax^n$ and $\pm Bx^{n-1}$ in the first line will have different signs; for, on account of the descending, $\pm Bx^{n-1}$ has a contrary sign to the term $\pm Aax^{n-1}$ below it, and, consequently, to $\pm Ax^n$ in the first line. Therefore the second and third terms in the polynome have different signs. But the like terms in the product have the same sign; for the second term in the product has the same sign with $\pm Ax^n$ in the first line; and the third term of the product has the same sign with $\pm Aax^{n-1}$ in the second line. Thus there is a continuation of the same sign introduced in the product, instead of a variation from one sign to another that takes place in the polynome; and the same thing is true at every descending.

In ascending from the second line to the first, there may either be a variation in the product instead of a continuation that exists in the polynome, or the contrary. But one of these two must take place.

Now it is evident that, except at the descendings and ascendings, there is the same number of continuations of the same sign, and the same number of variations from one sign to another, in the product and in the given polynome. Every descending introduces a continuation in the product instead of a variation existing in the polynome. And even if we suppose that every ascending introduces a variation in the product instead of a continuation that takes place in the polynome, yet, on the whole, there will be one continuation more in the product than in the polynome, because the descendings are one more than the ascendings.

In the preceding demonstration, it is supposed that all the ascendings have a contrary effect to the descendings, by which means there is introduced in the product the least possible number of variations from one sign to another in the one case, and the least possible number of continuations of the same sign in the other. But if, in the first case, we suppose that, at one ascending, there is a variation in the product, and a continuation in the polynome, this will add one to the variations in the product, and one to the continuations in the polynome; so that the variations in the product will now exceed those in the polynome by three, namely, by two more than in the circumstances supposed in the demonstration. And if we extend the like reasoning to two, three, &c. ascendings, the variations in the product will exceed those in the polynome respectively by five, seven, &c. The like conclusion is evidently true of the second case, *mutatis mutandis;* and hence the preceding proposition, when it is generalized as much as it can be, may be thus enunciated: "If any rational polynome be multiplied by $x - a$, the variations from one sign to another in the product will exceed those in the polynome by one, or three, or five, or by some odd number; and if it be multiplied by $x + a$, the continuations of the same sign in the product will exceed those in the polynome by one, or three, or five, or by some odd number."

Now, if we conceive that any rational polynome is resolved into its binomial factors, there will be a factor of the form $x - a$ for every positive root, and one of the form $x + a$ for every negative root; and when all the factors are multiplied together in order to reproduce the polynome, it follows, from what has been proved, that the product will contain at least one change from + to —, or from — to + 1, for every factor of the form $x - a$, or for every positive root; and at least one succession of + to +, or of — to — 1, for every factor of the form $x + a$, or for every negative root. Hence this rule, viz. "An equation cannot have more positive roots than it has variations from one sign to another, nor more negative roots than it has continuations of the same sign."

In general, this rule merely points out limits which the number of the positive and negative roots of an equation cannot exceed. But it gives no criterion by which we can certainly know that an equation has even one positive or one negative root, much less does it ascertain the exact number of each kind.

But if the proposed equation can be completely resolved into real binomial factors; in which case the total number of its roots will be equal to its dimensions, and consequently to the sum of all the variations from one sign to another, and of all the continuations of the same sign; it is evident that the number of the positive roots will be precisely equal to that of the variations, and the number of the negative roots precisely equal to that of the continuations. In this case, therefore, and in this case only, the rule of Descartes is perfect, ascertaining the exact number of each kind of roots in the proposed equation.

We subjoin some consequences that result from the principles laid down.

"If a polynome $f(x)$ of n dimensions be multiplied by $x-a$, or $x+a$; and, in the first case, if the number of variations from one sign to another be augmented by the odd number $2i+1$; or, in the second case, if the number of continuations of the same sign be augmented by $2i+1$; then the total number of the roots, positive and negative, of the proposed polynome, cannot be greater than $n-2i$."

For, when the multiplier is $x-a$, let m denote the number of the variations from one sign to another in the proposed polynome $f(x)$; then $m+2i+1$ will be the total number of variations in the product $(x-a)\times f(x)$; consequently the total number of continuations in $(x-a)\times f(x)$ will be equal to $(n+1)-(m+2i+1)$, or $n-m-2i$. But a polynome cannot have more negative roots than it has continuations of the same sign; wherefore the number of the negative roots of $(x-a)\times f(x)$ cannot be greater than $n-m-2i$. Now, the two polynomes $f(x)$ and $(x-a)\times f(x)$ have the same negative roots; and hence the number of the negative roots of $f(x)$ cannot exceed $n-m-2i$. But the number of the positive roots of $f(x)$ cannot exceed m; consequently the total number of the roots of $f(x)$ cannot be greater than $m+n-m-2i$; that is, than $n-2i$. And the proposition may be demonstrated in a similar manner when the multiplier is $x+a$.

"If one or several consecutive terms of an equation be wanting, and if the next terms on each side of those wanting have the same sign, the equation cannot have as many roots as it has dimensions."

Let the equation be $P+Q=0$, P and Q denoting the two parts on each side of the terms wanting. Having multiplied $P+Q$ by $x-a$, the product will be $(x-a)P+(x-a)Q$; and it is evident that we may consider P, Q, $(x-a)P$, $(x-a)Q$ as separate polynomes; hence, in each of the polynomes $(x-a)P$ and $(x-a)Q$, there will be at least one more variation from one sign to another than there is in P and Q. Again, in the polynome $P+Q$, there will be a continuation of the same sign in passing from P to Q; because the last term of P is supposed to have the same sign with the first term of Q. On the other hand, because the last term of $(x-a)P$ has a contrary sign to the last term of P; and the first term of $(x-a)Q$, the same sign with the first term of Q, it follows that, in the polynome $(x-a)P+(x-a)Q$, there will be a variation from one sign to another in passing from $(x-a)P$ to $(x-a)Q$. Therefore, on the whole, there will be at least three variations from one sign to another in $(x-a)P+(x-a)Q$, more than there is in $P+Q$. Consequently, by the last proposition, the number of all the roots of the proposed equation must be at least two less than its dimensions.

8. An important inquiry is, to find how many roots, that is, real roots, there are in any proposed equation. Much has been written on this subject, but not very successfully. No general method has been found that is practically useful. Many *criteria* have been contrived, by means of which we can certainly discover that roots are wanting in an equation, although we cannot infer the existence of the roots when the same criteria fail. But great value cannot be attached to such rules, since they are neither sufficient guides in practice, nor have much tendency to throw light on the theory.

Waring first, and nearly about the same time Lagrange, proposed a method which is successful in finding the conditions necessary in order that an equation have as many roots as it has dimensions, and which in all cases points out a limit that the number of the roots cannot exceed. This is effected by an auxiliary equation, and merely by the signs of its co-efficients, without requiring the computation of any of its roots. This procedure answers very well for equations of the third and fourth degrees; and it has even been extended by Waring to those of the fifth degree; but in this last case the calculation is very long, and would be altogether impracticable in the higher orders of equations. It is also not a little probable that this rule employs more conditions than are absolutely necessary for determining the point in question; there being great reason to think that some of them are implied in the rest, and are deducible from them. The method here alluded to depends upon the theory of trinomial divisors; and as it is much referred to by algebraists of the present day, we shall, in a subsequent part of this article, briefly explain the principles on which it is founded.

There is also another way of finding the number of real roots in an equation, which is general for all orders, and requires the solution of such equations only as are of lower dimensions than the one proposed. As to practical utility, indeed, this method is of little avail in equations passing the third and fourth degrees, or at most the fifth degree; but it is nevertheless not without interest, both because it is founded on the principles essential to the inquiry, and because it leads to some useful properties. Algebraists differ from one another in their exposition of this method. Some derive it from the theory of Harriot, namely, that every rational polynome is the product of as many binomial factors as it has dimensions; in which manner of proceeding the impossible roots are the occasion of uncertainty and embarrassment. Others, again, deduce it from the variations of magnitude which a rational polynome undergoes when the unknown quantity is made to pass through all possible degrees of increasing and decreasing. This last mode of investigation seems greatly to deserve the preference, being in reality the only one that is entirely unexceptionable, and requires no principles foreign to the research.

Suppose an equation, $x^n+Ax^{n-1}+Bx^{n-2}\ldots\ldots+Mx+N=0$, which we may denote by $f(x)=0$: substitute $x-i$ in place of x, and put

$$X=f(x)=x^n+Ax^{n-1}\ldots\ldots+Mx+N,$$

$$X'=nx^{n-1}+(n-1)Ax^{n-2}+(n-2)Bx^{n-2}\ldots+M,$$

$$X''=n\cdot\frac{n-1}{2}x^{n-2}+(n-1)\cdot\frac{n-2}{2}Ax^{n-3}+, \&c. \&c.$$

then the function $f(x-i)$ will be transformed into

$$X-X'.i+X''.i^2-X'''.i^3+, \&c.$$

If we suppose the notation of the differential calculus, the same transformation will be thus represented:

$$f(x) - \frac{d \,.\, f(x)}{dx} \,.\, i + \frac{1}{2} \,.\, \frac{d^2 \,.\, f(x)}{dx^2} \,.\, i^2 -, \text{\&c.};$$

which has the advantage of pointing out in what manner the several functions, X′, X″, &c. are derived from one another, and from the first function X, or $f(x)$.

Let α, β, γ, &c. denote the real roots of the equation $X = 0$, or $f(x) = 0$, arranged according to the order of their magnitude, that is, α greater than β, β greater than γ, and so on. In like manner, observing the same order of arrangement, let α', β', γ', &c. represent the roots of $X' = 0$, or $\frac{d \,.\, f(x)}{dx} = 0$; and, for the sake of simplicity, suppose that the equation $X' = 0$ has no equal roots.

The relations which the variations of the polynome X bear to the variations of x, depend upon the functions X′, X″, &c. and principally upon the first of these. If X′ be positive, X will decrease as x decreases; if X′ be negative, X will increase as x decreases; and if X′ pass from being positive to become negative, or the contrary, then x continuing to decrease, X will change from decreasing to increasing, or the contrary; that is, it will attain a minimum or a maximum value. What is here said is the foundation of the method taught in the differential calculus, for finding the maxima and minima of algebraic quantities.

Now, when x has a value great enough, the polynome X′ will have the same sign with its first term, that is, it will be positive; and it will continue positive so long as x is greater than α', the greatest root of the equation $X' = 0$; after which it will become negative. Hence, while x decreases to the limit α', the polynome $f(x)$, which is positive when x is sufficiently great, will continually decrease; and when $x = \alpha'$, $f(x)$ will pass from decreasing to increasing, or it will have a minimum value. Now if this minimum $f(\alpha')$ be positive, $f(x)$ has not decreased to zero, and the given equation will have no root greater than α'. If $f(\alpha') = 0$, then, because the two equations $X = 0$ and $X' = 0$, take place at the same time, the given equation will have two roots equal to α'. (Sect. 6.) *Lastly*, if $f(\alpha')$ be negative, the polynome $f(x)$ has decreased from being positive to be negative; and therefore it has passed through zero, and the given equation will have one root, viz. α greater than α'.

As x continues to decrease from α' to β', the polynome X′ being negative, $f(x)$ will continually increase. At the limit $x = \beta'$, X′ is first equal to zero, and then becomes positive; and $f(x)$ will therefore change from increasing to decreasing, or will attain a maximum value. If this maximum $f(\beta')$ be negative, the polynome $f(x)$ has not increased to zero, and the given equation will have no root between α' and β': if $f(\beta') = 0$, it will have two roots equal to β: and if $f(\beta')$ be positive, $f(x)$, in increasing from the negative quantity $f(\alpha')$ to the positive quantity $f(\beta')$, must have passed through zero, and the given equation will have one root, viz. β, between α' and β'.

In like manner, x continuing to decrease from β' to γ', the polynome $f(x)$ will decrease from the maximum $f(\beta')$ to the minimum $f(\gamma')$: if $f(\gamma')$ be positive, the proposed equation will have no root between β' and γ'; if $f(\gamma') = 0$, it will have two roots equal to γ'; and if $f(\gamma')$ be negative, it will have one root, viz. γ, between the limits β' and γ'.

As the function $f(x)$ must become a minimum or a maximum, or must pass from decreasing to increasing, or the contrary, between every two contiguous roots of the equation $f(x) = 0$; and as the limits where the changes take place are determined by the roots of the equation $X' = 0$; it follows that there must be at least one root of this last equation between every two contiguous roots of the first. Hence the equation $f(x) = 0$ cannot have as many roots as dimensions, unless the equation $X' = 0$ likewise have as many roots as dimensions; and in general we have this rule, which determines a limit that the number of the roots of an equation cannot surpass, although it may fall short of it: "The roots of an equation $f(x) = 0$ cannot exceed in number those of the equation $\frac{d f(x)}{dx} = 0$, by more than one."

But if we can find the roots of the equation $X' = 0$, which is always one degree lower than the proposed equation, we can thence discover exactly both the number and the limits of the roots of this last. For let α', β', γ', &c. be substituted in the polynome $f(x)$, and let the results be arranged in order, viz.

$$\underset{-}{f(\alpha')}, \underset{+}{f(\beta')}, \underset{-}{f(\gamma')}, \underset{+}{f(\delta')}, \text{\&c.}:$$

if these quantities are alternately negative and positive; the first, third, fifth, &c. which are all minima, having the sign *minus;* and the second, fourth, &c. which are all maxima, having the sign *plus;* then the proposed equation $f(x) = 0$ will have just one root more than the equation $X' = 0$. When some of the conditions fail, the roots of the proposed equation will fall short of the number specified. If one maximum have the sign *minus*, or one minimum the sign *plus*, two roots will be wanting in the proposed equation; and in general as many roots will disappear, as there are consecutive minima and maxima that have the same sign deducting one; unless the minima and maxima precede the greatest root, or come after the least root, in which cases there will be as many roots wanting as there are minima and maxima that have the same sign.

Since the series of functions, X, X′, X″, &c. are derived similarly from one another, we may prove, as has been done with respect to the two first, that the roots of any one are contained between the roots of that which follows it. Hence, if the given equation have as many roots as dimensions, every equation in the series will likewise have as many roots as dimensions; and if there be roots wanting in any one, there will be at least as many wanting in every equation preceding it in the series.

The connected equations necessarily terminate in one of the first degree, which gives a limit between the two roots of the quadratic immediately before it; in like manner, the roots of the quadratic are the limits of the roots of the cubic preceding it; and in this manner, by going through all the successive equations, we shall finally arrive at the limits of the roots of the proposed equation. This process has been called *La Methode des Cascades;* but the length of the calculations renders it useless in practice.

The procedure explained above would enable us to find the number of roots in an equation of any order, if we were in possession of rules for solving equations of the inferior degrees. For want of such rules, the practical advantage that can be derived from it is very limited. Mathematicians have therefore turned their attention to determine the point in question in a way that should not require the resolution of equations. They have sought to investigate rational functions of the co-efficients, which, by means of the signs they are affected with in every particular case, might indicate the number of roots the equation possesses. Of this nature is the method which Du Gua has given in the *Mémoires de Paris*, 1741, for finding the conditions necessary in order that an equation have as many roots as dimensions. By a process analogous to that of Du Gua, M. Cauchy, in an excellent *Me-*

moir, published in the sixteenth volume of the *Journal de l'Ecole Polytechnique*, has shown not only that the total number of the roots may in every case be discovered, but likewise that the numbers of the positive and negative roots may be separately ascertained. The principles of both these methods are to be found in the theory explained above; but as many considerations of some intricacy are involved in them, a particular account of them would exceed the limits of this article.

In what goes before, we have supposed that all the roots of the equation $X' = 0$ are unequal; and in order to complete the theory, it remains to notice the consequences that follow when the case is otherwise. Suppose, then, that $X' = (x - \lambda)^i \times Q$: And, in the first place, if λ be a root of the equation $f(x) = 0$, there will in reality be no exception to the general conclusion; because in this case it is known that the polynome $f(x)$ will be divisible by $(x - \lambda)^{i+1}$. (Sect. 6.) Now, the case just mentioned being set aside, if i be an even number, the polynome X', or $(x - \lambda)^i \cdot Q$, will be equal to zero when $x = \lambda$; but it will not change its sign when x, from being less, comes to be greater than λ. Hence the polynome $f(x)$ will neither attain a maximum nor a minimum value at the same limit; and it will have no root, either between λ and the next greater root of the equation $X' = 0$, or between λ and the next less root of the same equation. It appears, therefore, that when i is even, the number of the roots of the equation $f(x) = 0$, and their limits, will depend entirely upon the equation $Q = 0$. Again, when i is an odd number, the polynome X' will be equal to zero when $x = \lambda$, and it will likewise change its sign when x is taken on contrary sides of that limit: Consequently, when $x = \lambda$, the polynome $f(x)$ will be a maximum or a minimum; and the nature of its roots will depend upon the equation $(x - \lambda)\,Q = 0$. It is evident that we may extend the same conclusions to any two adjacent equations in the series,

$$X = 0,\ X' = 0,\ X'' = 0,\ X''' = 0, \text{ \&c.}$$

provided the one which stands lower in the series is reducible to the form $(x - \lambda)^i Q$; and that $x - \lambda$ is not a common divisor of both. We may likewise draw this general inference from the principles that have been explained, viz. "If, in the series of connected equations, any one be found which is divisible by $(x - \lambda)^{2i}$, or $(x - \lambda)^{2i+1}$, at the same time that $x - \lambda$ is not a divisor of the equation immediately preceding, there will be at least $2i$ roots wanting in this last equation, and in all that stand before it in the series."

The following not inelegant proposition is a consequence of what has just been proved: "The number of the roots of an equation of n dimensions, in which $2i$ or $2i + 1$, consecutive terms, are wanting, cannot be greater than $n - 2i$."

Let the equation be represented by

$$P + Q = 0;$$

supposing that $2i$, or $2i + 1$ terms, are wanting between P and Q. Therefore, if the first term of Q contain x^m, the last term of P will contain x^{m+2i+1}, or x^{m+2i+2}. Now, in the series of equations, we shall at length arrive at one from which all the quantities of Q are exterminated; which equation, if we use the notation of the differential calculus, is equivalent to

$$\frac{d^{m+1}P}{dx^{m+1}} = 0;$$

and it is divisible by x^{2i}, or x^{2i+1}: And as the one immediately preceding it in the series, viz.

$$\frac{d^m P}{dx^m} + \frac{d^m Q}{dx^m} = 0,$$

is not divisible by x, it follows, from what has been shown, that there will be at least $2i$ roots wanting in this last equation, and in all those that stand before it; consequently the proposed equation cannot have more than $n - 2i$ roots.

From this we learn that it is not always possible, at least by any operations with real quantities, to transform an equation into another in which any proposed number of the intermediate terms shall be wanting. For the terms to be taken away may be such that the transformed equation could not have the same number of real roots as the one given; but it is impossible, without introducing imaginary quantities, to transform an equation with a certain number of real roots into another with a different number of such roots.

9. In what goes before, we have sought for the roots and binomial divisors in the nature of the polynome. We are now to take an inverted view of the subject, and to consider a rational polynome as produced by the continued multiplication of as many binomial factors as it has dimensions; from which source there arises an interesting set of properties.

If we take the words root and binomial factor strictly in the sense in which we have hitherto used them, and as denoting real quantities only, nothing is more certain than that all polynomes cannot be generated by binomial factors. But it will afterwards be proved that every rational polynome can be completely exhausted by binomial and trinomial divisors; and if we admit the resolution of every trinomial divisor into two imaginary factors, we shall arrive, with all the rigour of which the investigation is capable, at the genesis of equations supposed by Harriot, which represents them as entirely composed of binomial factors, possible or impossible. Besides, in extending to all equations the conclusions obtained from the manner of generating them, it may be observed that the properties so obtained, being ultimately expressed in functions of the co-efficients from which the roots and generating factors have disappeared, are in a manner independent of the method of investigation. Such is the structure of the language of algebra, that the conclusions to which it leads, although deduced by reasoning from a hypothesis not strictly general, are nevertheless true in all cases, when they are finally disengaged from what is peculiar in the analysis.

Suppose a polynome, as

$$x^n - A^{(1)}x^{n-1} + A^{(2)}x^{n-3} \ldots \pm A^{(n-1)}x \mp A^{(n)},$$

which is produced by the multiplication of the n factors,

$$(x - \alpha) \cdot (x - \beta)(x - \gamma)(x - \delta), \text{ \&c.}$$

then, by actually multiplying the factors, and equating the like terms of the equivalent expressions, we shall get

$$A^{(1)} = \alpha + \beta + \gamma + \delta +, \text{ \&c.}$$
$$A^{(2)} = \alpha\beta + \alpha\gamma +, \text{ \&c.} + \beta\gamma +, \text{ \&c.}$$
$$A^{(3)} = \alpha\beta\gamma + \alpha\beta\delta +, \text{ \&c.} + \beta\gamma\delta +, \text{ \&c.}$$
$$A^{(4)} = \alpha\beta\gamma\delta +, \text{ \&c.}$$
&c.

Hence it appears that the co-efficient of the second term of the polynome, or $-A^{(1)}$, is equal to the sum of all the roots with their signs changed; the co-efficient of the third term, or $+A^{(2)}$, to the sum of all the products of every two roots; the co-efficient of the fourth term, or $-A^{(3)}$, to the sum of all the products of every three roots with their signs changed, and so on, the signs of the roots being always changed in the products of an odd number; and finally, the last term is the product of all the roots with their signs changed or not, according as their number is odd or even.

It is evident that the ultimate product of the binomial factors will always be the same, in whatever order they are multiplied; and hence the co-efficients of the polynome will consist of the same products, however the roots be interchanged among one another. Expressions of the kind just mentioned, which have constantly the same value, whatever change is made in the order of the quantities they contain, are called *invariable functions* and *symmetrical functions*. The co-efficients of an equation are the most simple symmetrical functions of the roots, from which it may be required, on the one hand to deduce all other functions of the like kind, and on the other to go back to the roots themselves. Most inquiries relating to equations are connected with one or other of these two problems; of which the first, like most direct methods, is attended with little difficulty, and has been completely solved; while the other, past equations of the fourth degree, has eluded all the attempts of algebraists.

After the co-efficients of the polynome, the next most simple symmetrical functions of the roots are the sums of the squares, cubes, &c. In the universal arithmetic of Sir Isaac Newton, a very elegant rule is given for computing the sum of any proposed powers of the roots; and as this rule is a fundamental point in the theory of equations, we subjoin an elementary investigation of it.

Of the binomial factors before set down, let the first $x-\alpha$ be left out, and having multiplied the rest together, let the product be

$$x^{n-1}-\varphi^{(1)}x^{n-2}+\varphi^{(2)}x^{n-3}-\varphi^{(3)}x^{n-4}+,\&c.;$$

in which expression $\varphi^{(1)}$ is the sum of all the roots β, γ, δ, &c. except the first α; $\varphi^{(2)}$ is the sum of the products of every two of them, and so on. Now, multiply by $x-\alpha$, and the product will be equivalent to the given polynome: hence we get

$$\begin{aligned}
A^{(1)}&=\alpha+\varphi^{(1)},\\
A^{(2)}&=\alpha.\varphi^{(1)}+\varphi^{(2)},\\
A^{(3)}&=\alpha.\varphi^{(2)}+\varphi^{(3)},\\
&\vdots\\
A^{(r)}&=\alpha.\varphi^{(r-1)}+\varphi^{(r)}.
\end{aligned}$$

Again, multiply these formulæ in order by α^{r-1}, α^{r-2}, α^{r-3}, &c.; then

$$\begin{aligned}
\alpha^{r}&=\alpha^{r},\\
A^{(1)}.\alpha^{r-1}&=\alpha^{r}+\alpha^{r-1}.\varphi^{(1)},\\
A^{(2)}.\alpha^{r-2}&=\alpha^{r-1}.\varphi^{(1)}+\alpha^{r-2}.\varphi^{(2)},\\
&\vdots\\
A^{(r-1)}.\alpha&=\alpha^{2}\varphi^{(r-2)}+\alpha.\varphi^{(r-1)},\\
A^{(r)}&=\alpha.\varphi^{(r-1)}+\varphi^{(r)};
\end{aligned}$$

nd, by adding and subtracting alternately, we get

$$\alpha^{(r)}-A^{(1)}.\alpha^{r-1}+A^{(2)}.\alpha^{r-2}\ldots\pm A^{(r-1)}.\alpha \mp A^{(r)}=\mp\varphi^{(r)},$$

n which expression $\varphi^{(r)}$ is the sum of all the products of dimensions of the roots β, γ, δ, &c. leaving out the first α.

In like manner, if we leave out the factor $x-\beta$, and multiply all the rest, and proceed as before, we shall get

$$\beta^{r}-A^{(1)}\beta^{r-1}+A^{(2)}\beta^{r-2}\ldots\pm A^{(r-1)}\beta\mp A^{(r)}=\pm\varphi'^{(r)},$$

the symbol $\varphi'^{(r)}$ being the sum of the products of r dimensions of all the roots, α, γ, δ, except the second β.

And if we next leave out the factor $x-\gamma$, and follow a like procedure, we shall get

$$\gamma^{r}-A^{(1)}.\gamma^{r-1}+A^{(2)}.\gamma^{r-2}\ldots\pm A^{(r-1)}.\gamma\mp A^{(r)}=\mp\varphi''^{(r)};$$

where $\varphi''^{(r)}$ represents the sum of the products of r dimensions of all the roots α, β, δ, &c. except the third γ.

If we procced similarly till every one of the n factors is left out in its turn, and then add all the results, we shall get

$$S_{r}-A^{(1)}S_{r-1}+A^{(2)}S_{r-2}\ldots\pm A^{(r-1)}S_{1}\mp nA^{(r)}=\mp\left\{\varphi^{(r)}+\varphi'^{(r)}+\varphi''^{(r)}+,\&c.\right\};$$

in which expression S_r is written for the sum of the r powers of the roots; S_{r-1} for the sum of the $(r-1)$ powers, and so on.

Every product in any one of the aggregate quantities $\varphi^{(r)}$, $\varphi^{(r)}$, $\varphi''^{(r)}$, &c., is found in $A^{(r)}$, which is the sum of the products of r dimensions of all the roots; and hence it is easy to perceive that the sum of all the aggregates must be a multiple of $A^{(r)}$. Take any product in $A^{(r)}$; then that product will not be contained in r of the quantities $\varphi^{(r)}, \varphi'^{(r)}, \varphi''^{(r)}$, &c.; because, in so many of them, one or other of the letters of the product will be wanting; but the same product will be contained once in every one of the $n-r$ remaining quantities, because in every one of these all the letters of the product will be contained. Every product in $A^{(r)}$ is therefore repeated $n-r$ times in the sum of the quantities $\varphi^{(r)}, \varphi'^{(r)}, \varphi''^{(r)}$, &c.; consequently,

$$\varphi^{(r)}+\varphi'^{(r)}+\varphi''^{(r)}+,\&c.=(n-r)\,A^{(r)}.$$

Substitute this value in the formula obtained above, and after transposing and cancelling $nA^{(r)}$, which appears with contrary signs, we shall get

$$S_{r}-A^{(1)}S_{r-1}+A^{(2)}S_{r-2}\ldots\pm A^{r-1}S\mp rA^{(r)}=0.$$

This is the rule of Sir Isaac Newton, and contains all his particular formulæ, as will readily appear by putting 1, 2, 3, &c. successively for r.

The preceding formula will enable us to compute, in succession, the sums of all the positive powers of the roots, both when r is less and when it is greater than the dimensions of the equation. But, in applying the formula in the latter case, we must observe that all the co-efficients of the polynome after $A^{(r)}$ are wanting, or equal to nothing.

If, in the first step of the preceding investigation, we take the co-efficients that follow $A^{(r)}$, we shall get

$$\begin{aligned}
A^{(r+1)}&=\alpha.\varphi^{(r)}+\varphi^{(r+1)},\\
A^{(r+2)}&=\alpha.\varphi^{(r+1)}+\varphi^{(r+2)},
\end{aligned}$$

$$\mathrm{A}^{(n-1)} = \alpha\varphi^{(n-2)} + \varphi^{(n-1)},$$

$$\mathrm{A}^{(n)} = \alpha \cdot \varphi^{(n-1)}.$$

And, by first dividing by α, α^2, α^3, &c. in order, and then subtracting and adding alternately, we shall obtain

$$\frac{\mathrm{A}^{(r+1)}}{\alpha} - \frac{\mathrm{A}^{(r+2)}}{\alpha^2} + \frac{\mathrm{A}^{(r+3)}}{\alpha^3} -, \&c. = \varphi^{(r)}.$$

In a similar manner we get

$$\frac{\mathrm{A}^{(r+1)}}{\beta} - \frac{\mathrm{A}^{(r+2)}}{\beta^2} + \frac{\mathrm{A}^{(r+3)}}{\beta^3} -, \&c. = \varphi'^{(r)},$$

$$\frac{\mathrm{A}^{(r+1)}}{\gamma} - \frac{\mathrm{A}^{(r+2)}}{\gamma^2} + \frac{\mathrm{A}^{(r+3)}}{\gamma^3} -, \&c. = \varphi''^{(r)}, \&c.$$

Therefore, by adding all these formulæ, and substituting for the sum of $\varphi^{(r)}$, $\varphi'^{(r)}$, &c. the value of it already found, we shall finally obtain

$$\mathrm{A}^{(r+1)}\,\mathrm{S}_{-1} - \mathrm{A}^{(r+2)}\,\mathrm{S}_{-2} + \mathrm{A}^{(r+3)}\,\mathrm{S}_{-3} -, \&c.$$
$$= (n-r)\,\mathrm{A}^{(r)},$$

the symbols S_{-1}, S_{-2}, &c. being put for the sums of the negative powers of the roots according to the indices underwritten. This formula will enable us to compute the sums of the negative powers of the roots.

If, in the formula for the sums of the positive powers of the roots, we make r successively equal to 1, 2, 3, &c. we shall get

$$\mathrm{A}^{(1)} = \mathrm{S}_1,$$
$$-2\mathrm{A}^{(2)} = -\mathrm{A}^{(1)}\,\mathrm{S}_1 + \mathrm{S}_2,$$
$$3\mathrm{A}^{(3)} = \mathrm{A}^{(2)}\,\mathrm{S}_1 - \mathrm{A}^{(1)}\,\mathrm{S}_2 + \mathrm{S}_3,$$
$$-4\mathrm{A}^{(4)} = -\mathrm{A}^{(3)}\,\mathrm{S}_1 + \mathrm{A}^{(2)}\,\mathrm{S}_2 - \mathrm{A}^{(1)}\,\mathrm{S}_3 + \mathrm{S}_4, \&c.$$

and from this we learn that the quantities S_1, S_2, S_3, &c. may be found by means of this expression, viz.

$$\frac{\mathrm{A}^{(1)} - 2\mathrm{A}^{(2)}\,z + 3\mathrm{A}^{(3)}\,z^2 \ldots \pm \mathrm{A}^{(n)}\,z^{n-1}}{1 - \mathrm{A}^{(1)}\,z + \mathrm{A}^{(2)}z^2 \ldots \pm \mathrm{A}^{(n)}\,z^n} = \mathrm{S}_1$$
$$+ \mathrm{S}_2 \cdot z + \mathrm{S}_3 \cdot z^2 +, \&c.$$

for if we multiply the series on the right-hand side of the sign of equality, by the denominator of the fraction on the other side, and then equate the co-efficients of the product to the like co-efficients of the numerator, we shall obtain the very formulæ set down above. Hence the sums of the powers of the roots expressed in terms of the co-efficients of the polynome will be found by developing the fraction in a series. In effecting the development different analytical methods may be followed; and the quantities sought will thus be obtained by different rules, or exhibited in expressions of different forms, such as those given by Waring, Vandermonde, Euler, and La Grange.

And in like manner, if, in the formula for the sums of the negative powers of the roots, we make r successively equal to $n-1$, $n-2$, $n-3$, &c. we shall get

$$\mathrm{A}^{(n-1)} = \mathrm{A}^{(n)}\,\mathrm{S}_{-1},$$
$$-2\mathrm{A}^{(n-2)} = -\mathrm{A}^{(n-1)}\,\mathrm{S}_{-1} + \mathrm{A}^{(n)}\,\mathrm{S}_{-2},$$
$$3\mathrm{A}^{(n-3)} = \mathrm{A}^{(n-2)}\,\mathrm{S}_{-1} - \mathrm{A}^{(n-1)}\,\mathrm{S}_{-2} + \mathrm{A}^{(n)}\mathrm{S}_{-3},$$
$$-4\mathrm{A}^{(n-4)} = -\mathrm{A}^{(n-3)}\,\mathrm{S}_{-1} + \mathrm{A}^{(n-2)}\,\mathrm{S}_{-2}$$
$$- \mathrm{A}^{(n-1)}\,\mathrm{S}_{-3} + \mathrm{A}^{(n)}\,\mathrm{S}_{-4},$$

&c.

from which it appears that the values of all the quantities S_{-1}, S_{-2}, S_{-3}, &c. will be obtained by means of this expression, viz.

$$\frac{\mathrm{A}^{(n-1)} - 2\mathrm{A}^{(n-2)}\,z + 3\mathrm{A}^{(n-3)}\,z^2 -, \&c.}{\mathrm{A}^{(n)} - \mathrm{A}^{(n-1)}\,z + \mathrm{A}^{(n-2)}\,z^2 -, \&c.} = \mathrm{S}_{-1}$$
$$+ \mathrm{S}_{-2} \cdot z + \mathrm{S}_{-3} \cdot z^2 +, \&c.$$

Two kinds of quantities only can enter into any rational and symmetrical function of the roots of an equation; and these are the sums of the like powers of the roots, and the sums of such products as, $\alpha^{i}\,\beta^{i'}\,\gamma^{i''}$, &c. which arise from multiplying different powers of the roots, two and two, three and three, &c. We shall now shortly point out in what manner the latter sums are deduced from the sums of the like powers, for the computation of which rules have already been given; by which means we shall be enabled to find the value of any proposed function of the kind above mentioned.

Let it be required to find the sum of all the products, such as $\alpha^{i}\beta^{i'}$, that arise from combining two powers of the roots in all possible ways; which sum may be denoted by the symbol $\Sigma \,.\, \alpha^{i}\beta^{i'}$. Now it is evident that the product, $\mathrm{S}_i \times \mathrm{S}_{i'}$, will contain two sorts of terms only, namely, powers of the roots, such as $\alpha^{i+i'}$, and the products of which the sum is sought; therefore

$$\Sigma \,.\, \alpha^{i}\beta^{i'} = \mathrm{S}_i \times \mathrm{S}_{i'} - \mathrm{S}_{i+i'}.$$

Next let it be required to find $\Sigma \,.\, \alpha^{i}\beta^{i'}\gamma^{i''}$, or the sum of all the products of three powers of the root. Now $\Sigma \,.\, \alpha^{i}\beta^{i'} \times \mathrm{S}_{i''}$ will contain three sorts of terms, namely, products, such as $\alpha^{i+i''}\,\beta^{i'}$ and $\alpha^{i'+i''}\,\beta^{i}$, in which two roots only are combined, and the products of which the sum is required; therefore

$$\Sigma \,.\, \alpha^{i}\beta^{i'}\gamma^{i''} = \Sigma\alpha^{i}\beta^{i'} \times \mathrm{S}_{i''}$$
$$- \Sigma \,.\, \alpha^{i+i''}\beta^{i'}$$
$$- \Sigma \,.\, \alpha^{i'+i''}\beta^{i}:$$

but, according to the last case,

$$\Sigma \,.\, \alpha^{i+i''}\,\beta^{i'} = \mathrm{S}_{i+i''} \times \mathrm{S}_{i'} - \mathrm{S}_{i+i'+i''},$$
$$\Sigma \,.\, \alpha^{i'+i''}\,\beta^{i} = \mathrm{S}_{i'+i''} \times \mathrm{S}_{i} - \mathrm{S}_{i+i'+i''}:$$

wherefore

$$\Sigma \,.\, \alpha^{i}\beta^{i'}\gamma^{i''} = \mathrm{S}_i \times \mathrm{S}_{i'} \times \mathrm{S}_{i''}$$
$$- \mathrm{S}_{i+i'} \times \mathrm{S}_{i''}$$
$$- \mathrm{S}_{i+i''} \times \mathrm{S}_{i'}$$
$$- \mathrm{S}_{i'+i''} \times \mathrm{S}_{i}$$
$$+ 2\mathrm{S}_{i+i'+i''}.$$

In like manner, when four different powers of the roots are multiplied together, we get

$$\Sigma . \alpha^{i}\beta^{i'}\gamma^{i''}\,\delta^{i'''} = \Sigma \,.\, \alpha^{i'}\,\beta^{i'}\,\gamma^{i''} \times \mathrm{S}_{i'''}$$
$$- \Sigma \,.\, \alpha^{i+i'''}\,\beta^{i'}\,\gamma^{i''}$$
$$- \Sigma \,.\, \alpha^{i'+i'''}\,\beta^{i}\,\gamma^{i''}$$
$$- \Sigma \,.\, \alpha^{i''+i'''}\,\beta^{i'}\,\gamma^{i};$$

and we have only to apply the preceding case in order to obtain the expression of the quantity sought in terms of the sums of the like powers of the roots.

According to the procedure just explained, the case where any number of powers are multiplied together, is reduced to the simpler case where the powers multiplied are one less. There would be no great difficulty in deducing a general formula for the sum when the products contain any proposed number of different powers; but this would lead to calculations incompatible with the length of this article; and it may be doubted whether the use of such a formula is preferable in any cases likely to occur in practice, to the application of the principles here laid down.

The theory of symmetrical functions is of the most extensive use in every branch of the doctrine of equations. Thus, if it be required to form an equation, the roots of which shall be any combinations of the roots of a given equation; it is manifest that the co-efficients of the equation sought will be symmetrical functions of the roots of the given equation; and hence they may be found by calculating these functions in terms of the co-efficients of the given equation.

The theory of symmetrical functions is also of use in approximating to the roots of numerical equations. Sir Isaac Newton seems to have had this application in view in giving his rule for computing the sums of the like powers of the roots. He observes that the powers of a great number increase in a much higher ratio than the same powers of less numbers; and hence the $2r^{\text{th}}$ power of the greatest root of an equation will approach nearer to the sum of the $2r^{\text{th}}$ powers of all the roots as r is greater. Wherefore, neglecting the distinction between positive and negative roots, if we calculate S_{2r}, and then extract its $2r^{\text{th}}$ root, we shall have an approximation to the root of the equation greatest in point of magnitude; and the approximation will be so much more accurate as r is greater.

But there is a more convenient way of approximating to the greatest and least roots of an equation, by means of symmetrical functions. For, since

$$S_{r+1} = \alpha^{r+1} + \beta^{r+1} +, \&\text{c.}$$

$$S_r = \alpha^r + \beta^r +, \&\text{c.}$$

we have

$$\frac{S_{r+1}}{S_r} = \alpha \cdot \frac{1 + \dfrac{\beta^{r+1}}{\alpha^{r+1}} +, \&\text{c.}}{1 + \dfrac{\beta^r}{\alpha^r} +, \&\text{c.}};$$

Now, α being the greatest root, the fraction on the right-hand side will approach to unit when r is sufficiently large, in which case $\dfrac{S_{r+1}}{S_r}$ will be nearly equal to α. Hence, if we compute a series of consecutive sums, viz. S_r, S_{r+1}, S_{r+2}, &c.; the values

$$\frac{S_{r+1}}{S_r}, \frac{S_{r+2}}{S_{r+1}}, \frac{S_{r+3}}{S_{r+2}}, \&\text{c.}$$

will approach nearer and nearer to the greatest root of the equation.

In like manner, if we take the sums of the negative powers of the roots, we shall have

$$\frac{S_{-r}}{S_{-r-1}} = \alpha \cdot \frac{1 + \dfrac{\alpha}{\beta^r} +, \&\text{c.}}{1 + \dfrac{\alpha^{r+1}}{\beta^{r+1}} +, \&\text{c.}};$$

from which it appears that $\dfrac{S_{-r}}{S_{-r-1}}$ will approximate so much more to α, the least root of the equation, as r is greater.

Trinomial Divisors.

10. We proceed next to consider the trinomial divisors of a given polynome; and, in order to avoid reference to other treatises, we shall begin with a short investigation of a preliminary point.

We have this identical expression,

$$x^2 - y^2 = (x+y) \cdot (x-y);$$

consequently,

$$(x^2 - y^2)^n = (x+y)^n \cdot (x-y)^n;$$

and again,

$$(x^2 - y^2)^n = \frac{1}{4} \cdot \left\{ (x+y)^n + (x-y)^n \right\}^2 - \frac{1}{4} \cdot \left\{ (x+y)^n - (x-y)^n \right\}^2$$

Now, using the letters H and G as the characteristics of the particular functions under consideration, let

$$\text{H}_n(x, y^2) = \frac{1}{2} \cdot \left\{ (x+y)^n + (x-y)^n \right\},$$

$$\text{G}_n(x, y^2) = \frac{1}{2} \cdot \frac{(x+y)^n - (x-y)^n}{y};$$

or by expanding the binomial quantities in series,

$$\text{H}_n(x, y^2) = x^n + n \cdot \frac{n-1}{2} \cdot x^{n-2} y^2 +, \&\text{c.}$$

$$\text{G}_n(x, y^2) = n x^{n-1} + n \cdot \frac{n-1}{2} \cdot \frac{n-2}{3} x^{n-3} y^2 +, \&\text{c.};$$

then, by means of these notations, the preceding expression will be thus written, viz.

$$(x^2 - y^2)^n = \left\{ \text{H}_n(x, y^2) \right\}^2 - y^2 \cdot \left\{ \text{G}_n(x, y^2) \right\}^2.$$

This equation is identical; that is, when the expressions on both sides of the sign of equality are expanded in series of terms containing the powers of y^2, they will consist of the same quantities with the same signs. It is evident, therefore, that the equation will still be identical if we change y^2 into $-y^2$; for by this change the simple quantities of the developed expressions will not be affected, and no alteration will be produced, except in the signs of the odd powers of y^2, which will now be contrary to what they were before. We therefore have

$$(x^2 + y^2)^n = \left\{ \text{H}_n(x, -y^2) \right\}^2 + y^2 \cdot \left\{ \text{G}_n(x, -y^2) \right\}^2;$$

in which equation it is to be observed that the functional expressions are not, as in the former instance, susceptible of an abridged algebraic notation, at least without introducing a new sign; but they can be exhibited in series, viz.

$$\text{H}_n(x, -y^2) = x^n - n \cdot \frac{n-1}{2} \cdot x^{n-2} y^2 + n \cdot \frac{n-1 \cdot n-2 \cdot n-3}{2 \cdot 3 \cdot 4} x^{n-4} y^2 -, \&\text{c.}$$

$$\text{G}_n(x, -y^2) = n x^{n-1} - n \cdot \frac{n-1 \cdot n-2}{2 \cdot 3} x^{n-3} y^2 +, \&\text{c.}$$

Now put $x = r \cos. \varphi$, $y = r \sin. \varphi$, $x^2 + y^2 = r^2$; and let $\varphi^{(n)}$ denote an arc, depending, in a certain manner, not yet discovered, upon the arc φ and the index n; then, in consequence of the equation obtained above, we shall have

$$r^n \cos. \varphi^{(n)} = \text{H}_n (x, -y^2),$$

$$r^n \sin. \varphi^{(n)} = y \text{G}_n (x, -y^2).$$

Again, multiply both sides of the same equation last referred to by $x^2 + y^2$; then

$$(x^2+y^2)^{n+1} = \left\{ x \,.\, \mathrm{H}_n(x,-y^2) - y^2 \mathrm{G}_n(x,-y^2) \right\}^2$$

$$+ y^2 \left\{ \mathrm{H}_n(x,-y^2) + x\mathrm{G}_n(x,-y^2) \right\}^2,$$

but, since the equation alluded to is general for all the values of n, we may write $n+1$ for n; and thus we get

$$(x^2+y^2)^{n+1} = \left\{ \mathrm{H}_{n+1}(x,-y^2) \right\}^2$$

$$+ y^2 \left\{ \mathrm{G}_{n+1}(x,-y^2) \right\}^2:$$

therefore, by comparing the two values of $(x^2+y^2)^{n+1}$

$$\mathrm{H}_{n+1}(x,-y^2) = x \,.\, \mathrm{H}_n(x,-y^2) - y^2\mathrm{G}(x,-y^2),$$

$$y\mathrm{G}_{n+1}(x,-y^2) = y\mathrm{H}_n(x,-y^2) + yx\mathrm{G}n(x,-y^2):$$

and finally, by substituting the values of the functions in terms of the arcs, φ, $\varphi^{(n)}$, $\varphi^{(n+1)}$, we shall obtain

$$\cos.\varphi^{(n+1)} = \cos.\varphi\cos.\varphi^{(n)} - \sin.\varphi\sin.\varphi^{(n)} = \cos.(\varphi^{(n)}+\varphi),$$

$$\sin.\varphi^{(n+1)} = \cos.\varphi\sin.\varphi^{(n)} + \sin.\varphi\cos.\varphi^{(n)} = \sin.(\varphi^{(n)}+\varphi),$$

$$\varphi^{(n+1)} = \varphi^{(n)} + \varphi.$$

Now, if we make n successively equal to 1, 2, 3, &c. the results will be,

$$\varphi^{(2)} = 2\varphi,$$

$$\varphi^{(3)} = 3\varphi,$$

&c.

and generally, $\varphi^{(n)} = n\varphi$.

Thus it appears that

$$r^n \cos.\, n\varphi = \mathrm{H}_n(x,-y^2),$$

$$r^{n-1} \times \frac{\sin.n\varphi}{\sin.\varphi} = \mathrm{G}_n(x,-y^2);$$

or, if we take the expanded expressions of the functions,

$$r^n \cos.\, n\varphi = x^n - n\,.\frac{n-1}{2}x^{n-2}y^2 +$$

$$n\,.\frac{n-1}{2}\,.\frac{n-2}{3}\,.\frac{n-3}{4}x^{n-4}y^2 -, \text{\&c.}$$

$$r^{n-1} \times \frac{\sin.n\varphi}{\sin.\varphi} = nx^{n-1} - n.\frac{n-1}{2}\,.\frac{n-2}{3}x^{n-3}y^2 +, \text{\&c.}$$

in which formulæ, $x = r\cos.\varphi$, $y = r\sin.\varphi$.

The functions here designated by the letters H and G may be expressed by means of the imaginary sign; for we have

$$\mathrm{H}_n(x,-y^2) = \frac{(x+y\sqrt{-1})^n + (x-y\sqrt{-1})^n}{2},$$

$$\mathrm{G}_n(x,-y^2) = \frac{(x+y\sqrt{-1})^n - (x-y\sqrt{-1})^n}{2y\sqrt{-1}};$$

And, in the case of $r=1$, the formulæ obtained above are equivalent to the expressions known in analysis since the time of Dr Moivre, viz.

$$\cos.\, n\varphi = \frac{(\cos.\varphi + \sin.\varphi\sqrt{-1})^n + (\cos.\varphi - \sin.\varphi\sqrt{-1})^n}{2}$$

$$\sin.\, n\varphi = \frac{(\cos.\varphi + \sin.\varphi\sqrt{-1})^n - (\cos.\varphi - \sin.\varphi\sqrt{-1})^n}{2\sqrt{-1}}.$$

But the mode of investigation we have followed is rigorous; and it has the advantage of leading to the true import of the imaginary sign, and of putting in a clear light its real effect in analytical operations. The real use of this sign may be shortly described by saying that it performs for even and odd functions the same office that the negative sign does for ordinary functions; in other words, when, by means of the ordinary operations of analysis, it has been proved that an even or odd function of an indeterminate quantity is equal to zero, it is by means of the impossible sign that the same equation is extended to the case when the square of the indeterminate quantity is negative. Every function of the indeterminate quantity x may be thus represented, viz.

$$\varphi(x^2) \pm x\Psi(x^2);$$

and the substitution of $x\sqrt{-1}$ in place of x, has no other effect than to change the preceding expression into the one following, viz.

$$\varphi(-x^2) \pm x\sqrt{-1}\,.\,\Psi(-x^2);$$

and from this it is obvious, that the same operations which, in the one case, lead us to the equations $\varphi(x^2)=0$ and $x\Psi(x^2)=0$, will, in the other, necessarily conduct us to the equations $\varphi(-x^2)=0$ and $x\,.\,\Psi(-x^2)=0$. It is to be observed, too, that the truth of the two latter equations is involved in that of the former. For the former equations cannot be generally true for all values of x^2, unless they are identical, or consist of equal quantities with opposite signs that mutually destroy one another; in which case the latter equations will also be identical. The sign of impossibility, as it has been called, is therefore one as truly significant as any other in analysis. It has, indeed, no consistent meaning when we consider it as only affecting x, or the indeterminate quantity to which it is joined; but it becomes perfectly intelligible when we contemplate the real changes produced by it in the functions of even and odd dimensions, in which its conclusions are always ultimately expressed. When the true import and real effect of the imaginary sign are clearly apprehended, the truth of its conclusion is no longer doubtful or mysterious, but follows as a necessary consequence of a fundamental principle of analytical language. Proceeding on this principle, we may even lay aside the imaginary character; and, in every particular case, with the assistance of a proper notation, arrive, by the ordinary operations, at the same conclusion to which it leads, as has been done in the preceding instance. It is to be observed further, that the imaginary arithmetic is not merely a short method of calculation convenient in practice, and that it may be dispensed with; it is strictly a necessary branch of analysis, without which, or some equivalent mode of investigation, that science would be extremely imperfect. The equations $\varphi(x^2)=0$ and $x\Psi(x^2)=0$, are unchangeable by any operations with the signs commonly received, by the use of which alone it is impossible to deduce, in a direct manner, the related equations $\varphi(-x^2)=0$ and $x\Psi(-x^2)=0$: although the latter are equally true, of as frequent occurrence, and as extensive application, as the former. Without the impossible sign the operations of algebra would, therefore, be defective; since there are analytical truths that could not be investigated in a direct manner by means of the elementary signs usually admitted. It is to supply this defect that the imaginary arithmetic has been introduced, and has grown up to be an extensive branch of analysis; advancing at first by slow steps, because the true import of the character it employs, and the real effect of its operations, were neither clearly perceived nor fully understood. But having premised what is conducive to our present purpose, we proceed to the investigation of the trinomial divisors of rational functions.

11. Every polynome of odd dimensions having at least one binomial factor, it may, by dividing by that factor, be reduced to another polynome one degree lower. And hence, in this part of our subject, we may confine our attention to polynomes of even dimensions. We may also suppose that the even polynomes under consideration have no double, triple, &c. factors of any kind: since, in case

ny such are present, they can be found separately and liminated by division.

Suppose, then, that $f(x)$ represents any polynome of ven dimensions; let $\varrho + u$ be substituted in place of x; nd, by using the notation of the differential calculus, the iven polynome will be transformed into

$$f(\varrho) + \frac{d.f(\varrho)}{d\varrho} \cdot u + \frac{1}{2} \cdot \frac{d^2 f(\varrho)}{d\varrho^2} \,.\, u^2 +, \&c.$$

Since $f(x)$ is an even po.ynome, the equation $\frac{df(x)}{dx} = 0$ ill be one of odd dimensions, having at least one root. et ϱ be the sole root of $\frac{df(x)}{dx} = 0$, when it has but one, nd the greatest root when it has several; then, because $\frac{f(\varrho)}{d\varrho} = 0$, the transformed function will become

$$f(\varrho) + \frac{1}{2} \cdot \frac{d^2 f(\varrho)}{d\varrho^2} u^2 + \frac{1}{6} \cdot \frac{d^3 f(\varrho)}{d\varrho^3} \,.\, u^3 +, \&c.$$

It readily appears, from what was formerly proved (Sect.), that ϱ, the greatest root of $\frac{df(x)}{dx} = 0$, exceeds the reatest root of any of the equations, $\frac{1}{2} \cdot \frac{d^2 f(x)}{dx^2} = 0$, $. \frac{d^3 f(x)}{dx^3} = 0$, &c.; and because, in any equation, the ıbstitution of a value greater than the greatest root must ive a positive result, all the quantities $\frac{1}{2} \cdot \frac{d^2 f(\varrho)}{d\varrho^2}$, $\frac{1}{6} \cdot \frac{d^3 f(\varrho)}{d\varrho^3}$, c. will be positive. With regard to $f(\varrho)$ it may be either ositive or negative, but not equal to zero; since this last se can happen only when the polynome has equal roots. he original polynome will, therefore, assume this form, z.

$$= y + A^{(2)}u^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots + A^{(2n-1)}u^{2n-1}$$

u^{2n}, in which expression y, $A^{(2)}$, $A^{(3)}$, &c. represent y positive quantities.

The most interesting proposition in the branch of the bject under consideration, is to prove that every polyme of even dimensions has a quadratic divisor, either the form $(u + \alpha)^2 - \tau^2$, which admits two real binoial factors, or of the form $(u - \alpha)^2 + \tau^2$, which has two aginary factors. By the preceding transformation this oposition is brought under two cases, according as y is fected with the sign *minus* or *plus*; the quadratic divir being always of the form $(u + \alpha)^2 - \tau^2$ in the first se, and always of the form $(u - \alpha)^2 + \tau^2$ in the other se; a distinction that agrees with what was before oved, Sect. 8.

Now the first of these cases is attended with no diffilty. For two values of u, one negative and one positive, ay be found that will satisfy the equation, Sect. 4.

$$y = A^{(2)}u^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots + u^{2n}.$$

f these values, it is obvious that the negative one will always greater than the positive one; and they may, erefore, be represented by $-(\tau + \alpha)$ and $\tau - \alpha$: where re, the polynome

$$-y + Au^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots\ldots + u^{2n},$$

ll be divisible by each of the binomial factors,

$$u + \tau + \alpha,$$
$$u - \tau + \alpha;$$

d likewise by the quadratic factor,

$$(u + \alpha)^2 - \tau^2,$$

oduced by their multiplication.

But the same mode of reasoning will not apply when y has the sign *plus*; in which case the demonstration must be deduced from other principles.

12. If we put

$$\varphi(u) = A^{(2)}u^2 + A^{(3)}u^3 + A^{(4)}u^4 \ldots + u^{2n},$$

the transformed polynome, supposing y to have the sign *plus*, will become

$$y + \varphi(u).$$

Let $(u - \alpha)^2 + \tau^2$ be a quadratic divisor of this polynome, and put $u - \alpha = z$, or $u = \alpha + z$; then, by substituting $\alpha + z$ for u, and writing all the terms of the transformed function $\varphi(\alpha + z)$ in two lines, one containing all the even and the other all the odd powers of z, the polynome $y + \varphi(u)$ will be equal to

$$y + \varphi(\alpha) + \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} \cdot z^2 + \frac{1}{24} \cdot \frac{d^4\varphi(\alpha)}{d\alpha^4} z^4 +, \&c.$$
$$+ z \,.\, \left\{ \frac{d\varphi(\alpha)}{d\alpha} + \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} \cdot z^2 +, \&c. \right\}.$$

By the same substitution of z for $u - \alpha$, the divisor $(u - \alpha)^2 + \tau^2$ is changed into the binomial quantity $z^2 + \tau^2$; which will be a divisor of each of the preceding lines, if $-\tau^2$, when it is substituted for z^2, render each of them equal to zero, Sect. 3. Hence we obtain the two following equations, viz.

$$0 = y + \varphi(\alpha) - \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} \tau^2 + \frac{1}{24} \cdot \frac{d^4\varphi(\alpha)}{d\alpha^4} \tau^4 -, \&c.$$
$$0 = \frac{d\varphi(\alpha)}{d\alpha} - \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} \tau^2 +, \&c. \qquad \text{(C)}$$

If two numbers, α and τ^2, can be found that will satisfy these equations, it is evident that $z^2 + \tau^2$ will be a divisor of each of the two lines that compose the transformed function $y + \varphi(\alpha + z)$; consequently it will be a divisor of the sum of both lines, or of the function itself, that is, $(u - \alpha)^2 + \tau^2$ will be a divisor of the proposed polynome $y + \varphi(u)$. We are now to prove that two such numbers may be found.

Substitute $\lambda^2 \alpha^2 - s$ for τ^2 in the equations (C), λ being a quantity to be afterwards determined; and, in order to shorten expressions, put

$$M = \varphi(\alpha) - \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} (\lambda^2 \alpha^2 - s) + \frac{1}{24} \cdot \frac{d^4\varphi(\alpha)}{a\alpha^4} \times$$
$$(\lambda^2 \alpha^2 - s)^2 - \&c.$$
$$N = \frac{d\varphi(\alpha)}{d\alpha} - \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} (\lambda^2 \alpha^2 - s) +, \&c.$$

And the two equations (C) will be thus written, viz.

$$y + M = 0,$$
$$N = 0.$$

In these equations α and s are always supposed to represent positive numbers, in which case the equation $N = 0$ cannot take place when s is greater than $\lambda^2 \alpha^2$; for then all the terms of N would be positive.

Considering N as a function of α, the part of it that does not contain α is evidently

$$A^{(3)} s + A^{(5)} s^2 + A^{(7)} s^3 +, \&c.$$

which is always positive. The highest power of α contained in the same function is α^{2n-1}; and we shall obtain all the terms of N that contain this power by putting α^{2n} for $\varphi(\alpha)$ in the expression

$$\frac{d\varphi(\alpha)}{d\alpha} - \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} \lambda^2 \alpha^2 + \frac{1}{120} \cdot \frac{d^5\varphi(\alpha)}{d\alpha^5} \lambda^4 \alpha^4 -, \&c.;$$

which terms are therefore as follows, viz.

$$\alpha^{2n-1} \Big\{ 2n - 2n . \frac{2n - 1 \,.\, 2n - 2}{2 \,.\, 3} \lambda^2 +$$

$$2n.\frac{2n-1.2n-2.2n-3.2n-4}{2\;.\;3\;.\;4\;.\;5}\lambda^4+,\&c.\Big\}.$$

Now, in the expression obtained in Sect. 10, viz.

$$r^{2n-1}\times\frac{\text{sin. }2n\varphi}{\text{sin. }\varphi}=2nx^{2n-1}-2n.\frac{2n-1.2n-2}{2\;.\;3}x^{2n-3}y^2+,\&c.$$

if we put $\lambda^2=\frac{y^2}{x^2}=\text{tan.}^2\,\varphi$, and divide both sides by $x^{2n-1}=r^{2n-1}\text{ cos.}^{2n-1}\varphi$; we shall obtain

$$\frac{\text{sin. }2n\varphi}{\text{sin. }\varphi}\times\frac{1}{\text{cos.}^{2n-1}\varphi}=2n-2n\cdot\frac{2n-1.2n-2}{2\;.\;3}\lambda^2+,\&c.;$$

from which formula it follows, that the polynome on the right-hand side of the sign of equality will be equal to nothing, where $\varphi=\pm\frac{m}{n}\times 90°$, m being any integer number less than n, zero not included. Wherefore the first, third, &c. roots of the polynome will be expressed by the formula

$$\lambda^2=\text{tan.}^2\frac{2k+1}{n}\cdot 90,$$

$2k+1$ representing any odd number less than n; and the second, fourth, &c. roots by the formula

$$\lambda^2=\text{tan.}^2\frac{2k+2}{n}\cdot 90°,$$

$2k+2$ being any even number less than n. And it is evident that the polynome will be negative for every value of λ^2 that lies between any odd root and the next even root, that is, for every value between these limits, viz.

$$\lambda^2>\text{tan.}^2\frac{2k+1}{n}\cdot 90°,$$

$$\lambda^2<\text{tan.}^2\frac{2k+2}{n}\cdot 90°.$$

Thus, an indefinite number of values of λ^2 may be found that will make the polynome negative.

Having assumed such a value of λ^2, let any positive number whatever be substituted for s, and N will be converted into a rational function of α; the greatest power of α, or α^{2n-1}, being odd, and having a negative co-efficient; and the term which does not contain α being positive. Wherefore at least one positive value of α may be found that will satisfy the equation $\text{N}=0$; and, as has already been observed, this value of α will be such as to make $\lambda^2\alpha^2-s$ a positive quantity. It is possible indeed that, in the equation $\text{N}=0$, there may be several values of α for every assumed value of s; but we here confine our attention to the least positive value, which is distinguished by this circumstance, that it vanishes with the absolute term of the equation, or with s; whereas, when s is equal to zero, all the other roots of the equation $\text{N}=0$ have finite values depending upon the given co-efficients.

Now, if we suppose s to increase from zero to infinity, and assume two values, s, and $s+\delta s$, very near one another, according to what has been proved, we shall have the corresponding values α and $\alpha+\delta\alpha$, such, that the equation $\text{N}=0$ will be satisfied by substituting both s and α, and likewise $s+\delta s$ and $\alpha+\delta\alpha$. Hence, because $\text{N}=0$, and $\delta\text{N}=0$, we get

$$\frac{d\text{N}}{d\alpha}.\delta\alpha+\frac{d\text{N}}{ds}.\delta s=0,$$

$$\text{and, }\delta\alpha=-\frac{\delta s}{\left(\frac{d\text{N}}{d\alpha}\right)}\times\frac{d\text{N}}{ds}.$$

Again, if we substitute first s and α, and then $s+\delta s$ and $\alpha+\delta\alpha$, in the function M, we shall get

$$\delta\text{M}=\frac{d\text{M}}{d\alpha}.\delta\alpha+\frac{d\text{M}}{ds}.\delta s.$$

But, by comparing the functions M and N, the following properties will readily be discovered, viz.

$$\frac{d\text{M}}{d\alpha}+2\lambda^2\alpha.\frac{d\text{M}}{ds}=\text{N}-2\frac{d\text{N}}{ds}(\lambda^2\alpha^2-s),$$

$$\frac{d\text{M}}{ds}=\frac{1}{2}\cdot\frac{d\text{N}}{d\alpha}+\lambda^2\alpha\cdot\frac{d\text{N}}{ds}:$$

whence,

$$\frac{d\text{M}}{d\alpha}=\text{N}-2\frac{d\text{N}}{ds}(\lambda^2\alpha^2-s)-\frac{d\text{N}}{d\alpha}\lambda^2\alpha-2\lambda^4\alpha^2\frac{d\text{N}}{ds}.$$

Consequently,

$$\delta\text{M}=\left\{\text{N}-2\frac{d\text{N}}{ds}(\lambda^2\alpha^2-s)-\frac{d\text{N}}{d\alpha}\lambda^2\alpha-2\lambda^4\alpha^2\cdot\frac{d\text{N}}{ds}\right\}\times\delta\alpha+\left\{\frac{1}{2}\cdot\frac{d\text{N}}{d\alpha}+\lambda^2\alpha\cdot\frac{d\text{N}}{ds}\right\}\cdot\delta s:$$

and, if we observe that $\text{N}=0$, and substitute the value of $\delta\alpha$ found above, we shall get

$$\delta\text{M}=\frac{-\delta s}{\left(\frac{d\text{N}}{d\alpha}\right)}\cdot-\left\{2\left(\frac{d\text{N}}{ds}\right)^2(\lambda^2\alpha^2-s)+\frac{1}{2}\left(\frac{d\text{N}}{d\alpha}+2\lambda^2\alpha\frac{d\text{N}}{ds}\right)^2\right\},$$

in which expression all the quantities are essentially positive, except $\frac{d\text{N}}{d\alpha}$, which is always negative, as may be thus proved.

The quantity s remaining invariable, if we make $\alpha=0$, the function N will be positive; for it is equal to

$$\text{A}^{(3)}s+\text{A}^{(5)}s^2+\text{A}^{(7)}s^3+,\&c.;$$

and the same function will continue positive, while α increases from zero to the least root of the equation $\text{N}=0$. At this limit N is first equal to zero, and then becomes negative; it must, therefore, be decreasing, and consequently $\frac{d\text{N}}{d\alpha}$ is negative. It may indeed happen, that, for particular values of s, the co-efficients of N may be such, that N and $\frac{d\text{N}}{d\alpha}$ shall be both equal to zero at the same time; but, in such cases, it will readily appear that $\frac{d\text{N}}{ds}$ and δM will likewise be equal to zero. Wherefore δM will be negative; at least, if it become equal to zero for any particular values of s and α, it cannot become positive. It follows, therefore, that the function M itself will be invariably negative, while s and α increase together from zero to be infinitely great.

Now assume a series of values of s increasing from zero without limit, viz.

$$0,\,s^{(1)},\,s^{(2)},\,s^{(3)},\,\ldots\ldots\,s^{(x)},\,s^{(x+1)}\ldots.$$

and having substituted these in the function N, find, by means of the equation $\text{N}=0$, the corresponding values of α, viz.

$$0,\,\alpha^{(1)},\,\alpha^{(2)},\,\alpha^{(3)},\,\ldots\ldots\,\alpha^{(x)},\,\alpha^{(x+1)}\ldots$$

then, by substituting these values in M, we shall obtain a series of results all negative, and increasing from zero without limit, viz.

$$0,-\text{M}^{(1)},-\text{M}^{(2)},-\text{M}^{(3)}..-\text{M}^{(x)},-\text{M}^{(x+1)}..$$

and whatever be the magnitude of the positive quantity y, it must be contained between two consecutive terms of this last series, viz. between $M^{(x)}$ and $M^{(x+1)}$. But as the values of s may be assumed as near one another as we please, it follows that $M^{(x)}$ and $M^{(x+1)}$ may be made to approach to one another and to y, within any required degree of accuracy. Thus two values of s and α may be found that will satisfy both the equations,

$$y + M = 0,$$
$$N = 0;$$

and having found these values, we shall obtain the quadratic divisor of the proposed polynome $y + \varphi(u)$, viz. $(u - \alpha)^2 + \tau^2$, or

$$(u - \alpha)^2 + \lambda^2\alpha^2 - s.$$

In the preceding demonstration it is supposed that M increases without limit, as s becomes indefinitely great; which may be thus proved: The values of M and N will coincide nearly with the terms containing the highest powers of s and α, when these quantities are very great; and ultimately the functions may be considered as equal to those terms alone. In such circumstances, therefore, the values of the functions will be found by writing α^{2n} for $\varphi(\alpha)$; whence we get

$$M = \alpha^{2n} - 2n \, . \, \frac{2n - 1}{2} \, . \, \alpha^{2n-2} \, (\lambda^2\alpha^2 - s) +, \&c.$$

$$N = 2n\,\alpha^{2n-1} - 2n \, . \, \frac{2n - 1 \cdot 2n - 2}{2 \quad . \quad 3} (\lambda^2\alpha^2 - s) +, \&c.$$

and if we put $\lambda^2\alpha^2 - s = t^2\alpha^2$, or $\alpha^2 = \dfrac{s}{\lambda^2 - t^2}$,

then $M = \alpha^{2n} \left\{ 1 - 2n \, . \, \dfrac{2n - 1}{2} \, . \, t^2 +, \&c. \right\}$

$$N = \alpha^{2n-1} \left\{ 2n - 2n \, . \, \frac{2n - 1 \cdot 2n - 2}{2 \quad . \quad 3} \, . \, t^2 +, \&c. \right\}$$

Now, s remaining invariable, α will increase as t^2 increases; and the least value of α that will satisfy the equation $N = 0$, corresponds to the least value of t^2 that will make the polynome in the expression of N equal to zero; which value, according to what was before shown, is

$$t^2 = \tan.^2 \frac{1}{n} \times 90°.$$

But, if we put $t = \tan.\ \varphi$, we shall get

$$M = \alpha^{2n} \times \frac{\cos.\ 2n\varphi}{\cos.^{2n} \varphi};$$

or, because $\varphi = \dfrac{1}{n} \times 90°$; $\cos.\ \varphi = \dfrac{1}{\sqrt{1 + t^2}}$,

and $\alpha^2 = \dfrac{s}{\lambda^2 - t^2}$;

$$M = - s^n \times \left(\frac{1 + t^2}{\lambda^2 - t^2} \right)^n;$$

which proves the point assumed in the demonstration.

By a similar mode of reasoning, we may likewise prove the former case of the proposition, when y is negative. In this case the quadratic divisor is $(u - \alpha)^2 - \tau^2$; and if we proceed as before, or, which is the same thing, if we change the signs of y and τ^2 in the equations (C) already obtained, and put

$$M = \varphi(\alpha) + \frac{1}{2} \cdot \frac{d^2\varphi(\alpha)}{d\alpha^2} \cdot \tau^2 +, \&c.$$

$$N = \frac{d\varphi(\alpha)}{d\alpha} + \frac{1}{6} \cdot \frac{d^3\varphi(\alpha)}{d\alpha^3} \tau^2 +, \&c.;$$

we shall get

$$- y + M = 0.$$
$$N = 0.$$

Now, by pursuing the steps of the foregoing analysis, we may prove, first, that, for every assumed value of τ^2, a negative value of α may be found, which will satisfy the equation $N = 0$; and, secondly, that when the values which satisfy the equation $N = 0$ are substituted in the function M, the results will be invariably positive; whence it follows that a positive value of τ^2, and a negative value of α, may be found that will satisfy both the equations, whatever be the magnitude of y. The analogy between the two cases is thus placed in a strong light; and a little reflection will even bring us to this conclusion, that in reality the one case is a necessary consequence of the other. For since α and τ^2 depend only upon y, and the given co-efficients of the polynome, they will be functions of y; wherefore, in the equations of the first case, viz.

$$- y + M = 0,$$
$$N = 0,$$

α being negative, and τ^2 positive, we may suppose $-\alpha = y\varphi(y)$ and $\tau^2 = y\,\Psi(y)$, these values being such as to render each of the equations identical; and then the quadratic divisor $(u - \alpha)^2 - \tau^2$ will become

$$\left\{ u + y\,\varphi(y) \right\}^2 - y\Psi(y).$$

But, because the foregoing equations become identical by the substitution of the values mentioned, it is a necessary consequence that the equations of the second case, viz.

$$y + M = 0,$$
$$N = 0,$$

in which the signs of y, α, and τ^2, are contrary to what they were in the former equations, will likewise be identical, when $-\alpha = -y\varphi(-y)$ and $\tau^2 = -y\Psi(-y)$; and the quadratic divisor, $(u - \alpha)^2 - \tau^2$, will now become

$$\left\{ u - y\varphi(-y) \right\}^2 + y\Psi(-y).$$

Thus, when the quadratic divisor of the first case is expressed in terms of y, we have only to change the sign of that quantity, in order to have the quadratic divisor of the second case. It is not difficult to perceive, that what has now been proved is nothing more than another application of the principle employed in Sect. 10: a principle which is the real foundation of the imaginary arithmetic, with the processes of which the preceding investigations are intimately connected. None but real quantities have occurred in the analysis we have pursued, because we have sought to investigate τ^2, which is always rational; whereas, if we had proposed to find τ, we should inevitably have been led to the real quantity $\sqrt{y}$ in the one case, and to the impossible quantity $\sqrt{-y}$ in the other. These few observations are made for the purpose of throwing light upon a part of analysis which is certainly obscure in its principles, although there is no question that it is a useful, and even a necessary branch of the art of calculation. A fuller elucidation of the subject would be unsuitable to this place; but enough has been said to show that we must seek in the principles of analysis itself for the explanation of the operations it employs; and we may with great probability conclude that no satisfactory account of the imaginary calculus will ever be obtained by having recourse to fanciful geometrical constructions, or to the analogy between the circle and the hyperbola, or to the metaphysical proposition, that all processes with general symbols, whether significant or not, are equally entitled to be considered as demonstrative.

13. Having now proved, in a rigorous manner, that every polynome of even dimensions has at least one quadratic divisor of the one kind or the other, it follows that it may be reduced by division to another polynome two degrees lower: in like manner, this last polynome will admit of being lowered two degrees more; and by repeating the same process, the first polynome will at length be completely exhausted by quadratic divisors. If, therefore, we recollect, that every polynome of odd dimensions has one binomial divisor, we shall arrive at this general conclusion, " That every rational polynome can be completely exhausted by binomial and trinomial divisors; and, consequently, that it is equal to the product of a certain number of factors of the two first degrees."

It appears also that the binomial factors of any polynome are such only as arise from the resolution of the quadratic divisors; and they are, therefore, either real or imaginary. And thus we finally obtain the following proposition, which was assumed by Harriot, and is the foundation of the received theory of equations, namely, " Every rational polynome has as many binominal factors, and as many roots, real and imaginary, as it has dimensions."

The necessity of confirming, by a general demonstration, the assumed theory of the impossible roots of equations, was early felt; and accordingly, this point has engaged the attention of all the great mathematicians to whom analysis is indebted for the progress it has made in the course of the last and the present centuries. An account of their several researches would greatly exceed the limits of this article; but the reader will find all the information he can wish for in two long notes (9 and 10) of the *Traité des Equations Numeriques*, by La Grange, in which the author, with his usual elegance, has explained and commented upon the various modes of investigation that have been proposed. It will be sufficient to observe here, that all the demonstrations that have appeared are either calculations with impossible quantities, or they proceed upon the assumption that every equation has as many roots as dimensions, and thus involve the very thing to be proved.

14. The general cases in which mathematicians have been successful in resolving rational functions into their trinomial factors, are confined to the theorem of Cotes, and to a more general proposition of a similar kind, for which we are indebted to De Moivre. These instances are of great importance in analysis, and we shall therefore subjoin an investigation of them, because they are deduced in a very direct manner from the method we have followed.

Suppose, as before, that $f(x)$, or $x^n + A^{(1)}x^{n-1} + A^{(2)}x^{n-2} \ldots + A^{(n-1)}x + A^{(n)}$, is a rational polynome of n dimensions, and $(x-\alpha)^2+\tau^2$ one of its quadratic divisors; put $z = x - \alpha$, substitute $\alpha + z$ for x, and write the transformed function in two lines, one containing all the even, and the other all the odd powers of z; then the polynome will be equal to

$$f(\alpha) + \frac{1}{2}\cdot\frac{d^2f(\alpha)}{d\alpha^2}z^2 + \frac{1}{24}\cdot\frac{d^4f(\alpha)}{d\alpha^4}z^4 -, \&c.$$

$$+ z \times \left\{ \frac{df(\alpha)}{d\alpha} + \frac{1}{6}\ \frac{d^3f(\alpha)}{d\alpha^3}z^2 + \frac{1}{120}\cdot\frac{d^5f(\alpha)}{d\alpha^5}z^4, \&c. \right\}$$

By the same substitution of z for $x - \alpha$, the divisor $(x-\alpha)^2 + \tau^2$ will become $z^2 + \tau^2$; and, as before, the conditions that $z^2 + \tau^2$ shall divide each of the foregoing lines, will be expressed by the following equations, viz.

$$0 = f(\alpha) - \frac{1}{2}\cdot\frac{d^2f(\alpha)}{d\alpha^2}\tau^2 + \frac{1}{24}\cdot\frac{d^4f(\alpha)}{d\alpha^4}\tau^4 -, \&c. \quad \text{(D)}$$

$$0 = \frac{df(\alpha)}{d\alpha} - \frac{1}{6}\cdot\frac{d^3f(\alpha)}{d\alpha^3}\tau^2 + \frac{1}{120}\cdot\frac{d^5f(\alpha)}{d\alpha^5}\tau^4 -, \&c.$$

In these formulæ substitute the expanded values of $f(\alpha), \frac{df(\alpha)}{d\alpha}$, &c.; and class together all the homogeneous terms of the same order, that is, all the terms in which the exponents of α and τ amount to the same sum, then we shall have

$$0 = \alpha_n - n.\frac{n-1}{2}\alpha^{n-2}\tau^2 +, \&c.$$

$$+ A^{(1)}.\left\{\alpha^{n-1} - n-1.\frac{n-2}{2}.\alpha^{n-3}\tau^2 +, \&c.\right\}$$

$$+ A^{(2)}.\left\{\alpha^{n-2} - n-2.\frac{n-3}{2}\alpha^{n-4}\tau^2 +, \&c.\right\}$$

$$\&c.$$

$$0 = n\alpha^{n-1} - n.\frac{n-1.n-2}{2\ .\ 3}\alpha^{n-3}\tau^2 +, \&c.$$

$$+ A^{(1)}.\left\{(n-1)\alpha^{n-2} - n-1.\frac{n-2.n-3}{2\ .\ 3}\alpha^{n-4}\tau^2 +, \&c.\right\}$$

$$+ A^{(2)}.\left\{(n-2)\alpha^{n-3} - n-2.\frac{n-3.n-4}{2\ .\ 3}\alpha^{n-5}\tau^2 +, \&c.\right\}$$

$$\&c.$$

Now, put $\alpha = r \cos.\varphi$, $\tau = r \sin.\varphi$; and, by what was proved in Sect. 10, the two foregoing equations will become

$$r^n \cos.n\varphi + A^{(1)}r^{n-1}\cos.(n-1)\varphi \ldots\ldots + A^{(n-1)}r\cos.\varphi$$

$$+ A^{(n)} = 0, \quad \text{(E)}$$

$$\frac{1}{\sin.\varphi}.\left\{ r^{n-1}\sin.n\varphi + A^{(1)}r^{n-2}\sin.(n-1)\varphi \ldots\ldots \right.$$

$$\left. + A^{(n-)}\sin.\varphi \right\} = 0:$$

And the quadratic divisor $(x-\alpha)^2 + \tau^2$ will be changed into

$$x^2 - 2r\cos.\varphi.x + r^2.$$

When $\sin.\varphi = 0$, and $\varphi = 0$ or 180°, the preceding equations coincide with these, viz.

$$r^n \pm A^{(1)}r^{n-1} + A^{(2)}r^{n-2} \pm, \&c. = 0$$

$$nr^{n-1} \pm (n-1)A^{(1)}r^{n-2} + (n-2)A^{(2)}r^{n-3} \pm, \&c. = 0,$$

which express the condition that the given polynome has two or more factors equal to $x \mp r$; at which limits a quadratic divisor changes from being of the form $(x-\alpha)^2 - \tau^2$ to be of the form $(x-\alpha)^2 + \tau^2$, or the contrary. Thus we learn that, in the equations (E), $\sin.\varphi$ must always have a finite value, and then the denominator of the second equation may be neglected.

Let the preceding investigation be applied to find the quadratic factors of $x^n - a^n$. In this case the two equations (E) will become

$$r^n \cos.n\varphi - a^n = 0$$

$$r^{n-1} \times \frac{\sin. n\varphi}{\sin. \varphi} = 0;$$

whence

$$r = a,$$
$$\cos. n\varphi = 1,$$
$$\frac{\sin. n\varphi}{\sin. \varphi} = 0.$$

Now, excluding the cases when $\varphi = 0$ and $\varphi = 180°$, the last equation will be satisfied when $\varphi = \frac{2k+1}{n} \times 180°$, or $\varphi = \frac{2k}{n} \times 180°$, the numerators of the fractions representing all the odd and even numbers less than the common denominator; but the second equation will be satisfied only when $\varphi = \frac{2k}{n} \times 180°$; wherefore all the quadratic factors of the function $x^n - a^n$ will be comprehended in the formula

$$x^2 - 2ax \times \cos. \frac{2k}{n} \times 180° + a^2.$$

When n is an even number, the quadratic factors will amount to $\frac{n-2}{2}$; and if to them we add the simple factors $x + a$ and $x - a$, we shall have the complete resolution of the function. When n is odd, the number of quadratic factors is $\frac{n-1}{2}$, to which must be added the binomial factor $x - a$.

By proceeding in a similar manner in the case of the function $x^n + a^n$, we shall have the equations

$$r = a,$$
$$\cos. n\varphi = -1,$$
$$\frac{\sin. n\varphi}{\sin. \varphi} = 0.$$

Excluding the cases when $\varphi = 0$ and $\varphi = 180°$, the second and third equations will be both satisfied, when $\varphi = \frac{2k+1}{n} \times 180°$, the numerator of the fraction representing any odd number less than n. Wherefore all the quadratic factors will be comprehended in the formula

$$x^2 - 2ax \times \cos. \frac{2k+1}{n} \times 180° + a^2.$$

When n is even, the number of quadratic factors is $\frac{n}{2}$, and they exhibit the complete resolution of the function. When n is odd, the number of quadratic factors is $\frac{n-1}{2}$, to which the binomial factor $x + a$ must be added.

Let us next take the more general function.

$$x^{2n} - 2\beta x^n a^n + a^{2n}.$$

And, in the first place, when β is greater than unit, the function is equal to

$$\left\{x^n - a^n(\beta + \sqrt{\beta^2 - 1})\right\} \times \left\{x^n - a^n(\beta - \sqrt{\beta^2 - 1})\right\};$$

and the quadratic factors may be found by the cases already considered.

When β is less than unit, let $\beta = \cos. \theta$, and the function to be resolved will be

$$x^{2n} - 2a^n x^n \cos. \theta + a^{2n}.$$

By means of the equations (E) we get

$$r^{2n} \cos. 2n\varphi - 2a^n r^n \cos. \theta \cos. n\varphi + a^{2n} = 0,$$
$$r^{2n-1} \times \frac{\sin. 2n\varphi}{\sin. \varphi} - 2a^n r^{n-1} \times \frac{\sin. n\varphi}{\sin. \varphi} \times \cos. \theta = 0;$$

and hence

$$r = a,$$
$$\cos. 2n\varphi - 2 \cos. \theta \cos. n\varphi + 1 = 0,$$
$$\frac{\sin. 2n\varphi}{\sin. \varphi} - 2 \frac{\sin. n\varphi}{\sin. \varphi} \times \cos. \theta = 0.$$

But, $\cos. 2n\varphi + 1 = 2 \cos.^2 n\varphi$; and $\sin. 2n\varphi = 2 \cos. n\varphi \times \sin. n\varphi$; wherefore the two last equations will become

$$2 \cos. n\varphi (\cos. n\varphi - \cos. \theta) = 0,$$
$$2 \frac{\sin. n\varphi}{\sin. \varphi} (\cos. n\varphi - \cos. \theta) = 0:$$

and these, supposing $\cos. \theta$ different from unit, can be satisfied only by making $\cos. n\varphi - \cos. \theta = 0$, or

$$\cos. n\varphi = \cos. \theta.$$

Now, $\cos. \theta = \cos. (m \times 360° + \theta)$, m being any integer number whatever, zero included; and hence $\varphi = \frac{m \times 360° + \theta}{n}$, which formula comprehends all the values of θ that will satisfy the above equations. Wherefore all the factors sought will be contained in this general expression, viz.

$$x^2 - 2ax \cos. \frac{m \times 360° + \theta}{n} + a^2;$$

in which, if for m we substitute all the integer numbers less than n, zero included, we shall obtain the n quadratic factors of the proposed function.

15. The quadratic divisors $(x - \alpha)^2 - r^2$ and $(x - \alpha)^2 + r^2$, have hitherto been considered separately; but they may be both represented by $(x - \alpha)^2 - s$, which will coincide with the one or the other, according as s is positive or negative. And, if we now proceed as before, we shall get the following equations, which express the conditions necessary, in order that the polynome $f(x)$ of any proposed dimensions, as n, shall be divisible by $(x - \alpha)^2 - s$, viz.

$$0 = f(\alpha) + \frac{1}{2} \cdot \frac{d^2 f(\alpha)}{d\alpha^2} s + \frac{1}{24} \cdot \frac{d^4 f(\alpha)}{d\alpha^4} \cdot s^2 +, \&c.$$
$$0 = \frac{df(\alpha)}{d\alpha} + \frac{1}{6} \cdot \frac{d^3 f(\alpha)}{d\alpha^3} \cdot s + \frac{1}{120} \cdot \frac{d^5 f(\alpha)}{d\alpha^5} s^2 +, \&c.$$

By eliminating s we shall obtain an equation, viz.

$$A = 0,$$

in which α is the unknown quantity. As the process of elimination is independent of the particular values of the co-efficients of $f(x)$, the degree of the resulting equation will be the same when the polynome $f(x)$ has as many real roots as dimensions, and when the case is otherwise. But when $f(x)$ is equal to the product of n real binomial factors, the multiplication of every two of them will form a quadratic factor. The number of such factors will, therefore, be equal to $n \times \frac{n-1}{2}$, which expresses all the combinations made with n things taken two and two. Consequently, there will be just so many different values of α that will satisfy the equation $A = 0$, which will, therefore, have its exponent equal to $n \times \frac{n-1}{2}$. It thus appears that the equation $A = 0$ rises in its dimensions very rapidly above the given polynome, on which account little advantage is derived from this procedure.

Again, by eliminating α from the same two equations, we shall obtain one, viz.

$$S = 0,$$

in which s is the unknown quantity. This equation, which has already been alluded to (Sect. 8), rises to the same dimensions with the former equation, $A = 0$; but it is possessed of some useful properties, derived chiefly from the consideration that every positive root gives a quadratic factor of the form $(x - \alpha)^2 - \tau^2$ in the polynome $f(x)$, and every negative root a quadratic factor of the form $(x - \alpha)^2 + \tau^2$ in the same polynome.

The quadruple of s is equal to the square of the difference of the two binomial factors of $(x - \alpha)^2 - s$; whence it follows that the quadruples of the several roots of the equation $S = 0$ are equal to the squares of the differences of the roots of $f(x) = 0$. If, therefore, we put x', x'', x''', &c. for the roots of $f(x) = 0$, the roots of $S = 0$ will be

$$\frac{1}{4}(x' - x'')^2,\ \frac{1}{4}(x' - x''')^2,\ \frac{1}{4}(x'' - x''')^2,\ \text{\&c.};$$

and from this it is manifest that the co-efficients of the same equation will be known symmetrical functions of the quantities x', x'', x''', &c. or of the roots of $f(x) = 0$. The rules formerly explained may, therefore, be employed for calculating the co-efficients of $S = 0$; and this method of forming the equation is not only more convenient than the process of eliminating, but it likewise has the advantage of enabling us to find any one co-efficient separately without computing the rest. Thus, if we put

$$K^{(n)} = (x' - x'')^2 \cdot (x' - x''')^2 \cdot (x'' - x''')^2 \cdot \text{\&c.}$$

and expand this product, and in place of the symmetrical functions of which it is composed, substitute their values in terms of the given co-efficients of $f(x) = 0$, we shall obtain the value of $K^{(n)}$; and the last term of the equation $S = 0$ will be equal to

$$\pm \frac{K^{(n)}}{2^{n(n-1)}}$$

the upper sign taking place when $n \times \frac{n-1}{2}$, the dimensions of the equation $S = 0$ is even, and the lower sign when the same number is odd.

If we suppose the given equation $f(x) = 0$ to be possessed of as many real roots as dimensions, or to have n real binomial factors, the product of every two of these will be a quadratic factor $(x - \alpha)^2 - s$, in which s is positive; wherefore, the roots of $S = 0$ will be all real and all positive. On the other hand, when the given equation $f(x) = 0$ has not as many real roots as dimensions, it will be divisible by one or more quadratic factors not resolvable into real binomial factors, and in which s is negative; consequently, the equation $S = 0$ will have one or more negative roots. It is, therefore, a property of the auxiliary equation $S = 0$, that when the roots are all real they are all positive, and when they are not all real some of them are negative. Now the rule of Descartes will enable us to find whether the roots are all positive or not; and by this means we shall discover whether the roots of the given equation $f(x) = 0$ are all real or not. From what has been said, we may lay down this rule: "The proposed equation $f(x) = 0$ will have all its roots real when the auxiliary equation $S = 0$ has as many variations from one sign to another as it has dimensions, or when its terms are alternately positive and negative; otherwise the proposed equation will have one or more quadratic factors of the form $(x - \alpha)^2 + \tau^2$, but the number of such factors cannot exceed the continuations of the same sign in the auxiliary equation."

Again, in the equation $S = 0$, the polynome S is equal to a certain number of binomial factors of the forms $x - a$ and $x + a$, multiplied into a supplementary polynome of even dimensions, which, not being capable of having a negative value, will have its last term positive (Sect. 5). It is manifest, therefore, that the last term of $S = 0$ will be positive or negative, according as the number of factors of the form $x - a$ is even or odd, that is, according as the equation has an even or odd number of real and positive roots. But every two real roots in the equation $f(x) = 0$ give one real and positive root in the subsidiary equation $S = 0$; wherefore, if m denote the number of real roots in the former equation, the number of real and positive roots in the latter will be equal to $m \times \frac{m-1}{2}$; and the last term of the subsidiary equation will be positive or negative, according as $m \times \frac{m-1}{2}$ is an even or an odd number.

In a cubic equation $x^3 + px + q = 0$, m is either one or three. In the first case, the equation $S = 0$ will have no positive roots, and the last term will be positive; in the second case, it will have three real and positive roots, and the last term will be negative. Now the dimensions of $S = 0$ being odd, the function $K^{(3)}$ will be negative in the first case and positive in the second. Wherefore the given cubic equation will have one real root, or three, according as the function $K^{(3)}$, that is,

$$(x' - x'')^2 \cdot (x' - x''')^2 \cdot (x'' - x''')^2,$$

or $-4p^3 - 27q^2$, is negative or positive.

In a biquadratic equation $x^4 + px^2 + qx + r = 0$, m is equal to zero, or two, or four. In the first case the equation $S = 0$ has no positive roots, in the third it has six, and in both cases the last term is positive. In the second case the same equation has only one real and positive root, and the last term is negative. The dimensions of $S = 0$, equal to $\frac{4 \times 3}{2}$, being even, the function $K^{(4)}$ will be positive in the first and third cases, and negative in the second case. Wherefore the proposed biquadratic equation will have only two real roots when the function $K^{(4)}$, that is,

$(x' - x'')^2 \cdot (x' - x''')^2 \cdot (x' - x^{\mathrm{IV}})^2 \cdot (x'' - x''')^2 \cdot (x - x^{\mathrm{IV}})^2 \cdot (x''' - x^{\mathrm{IV}})^2$, or, $256r^3 - 128p^2r^2 + 144q^2pr + 16p^4r - 27q^4 - 4q^2p^3$, is negative; and when the same function is positive, the proposed equation will have four real roots, if the terms of the auxiliary equation $S = 0$ be alternately positive and negative; otherwise it will have no real roots.

In an equation of the fifth degree, m is equal to one, or three, or five. In the first and third cases the last term of $S = 0$ will be positive, for there are either no positive roots or ten; in the second case the last term is negative, the number of positive roots being three. The dimensions of $S = 0$, equal to $\frac{5 \times 4}{2}$, being even, the function $K^{(5)}$ will be positive in the first and third cases, and negative in the second. Wherefore the given equation of the fifth degree will have three real roots when the function $K^{(5)}$ is negative; and when the same function is positive, it will have five real roots if the terms of the auxiliary equation $S = 0$ be alternately positive and negative; otherwise it will have but one.

Resolution of Algebraic Equations.

16. When the co-efficients of an equation are given in

numbers, we may investigate the numerical value of any one root separately, by first seeking the limits between which it lies, and then narrowing those limits to any required degree of approximation. But this process is not what is meant by the general solution of algebraical equations, which supposes that the co-efficients are denoted by general symbols, and consists in finding such a function of those quantities as shall, by the multiplicity of its values, represent all the roots. An algebraical expression is susceptible of many values, by means of the different radical quantities it contains; but these radical quantities being themselves the roots of an equation, it follows that the general formula for the solution of any proposed equation can be nothing more than a function of the given co-efficients combined with the roots of another equation.

The solution of quadratic equations has been known since the origin of algebra; it is found in the work of Diophantus, the first treatise on the science extant, if it be not the very first that was written. The Italian mathematicians, who are the founders of the modern algebra, discovered the solution of cubic and biquadratic equations. The rules they invented for this purpose are, however, rather the result of particular artifices than deductions from any profound views of the structure of the equations they considered. In the course of the last and the present centuries, the general solution of equations has been the subject of almost innumerable researches by all the mathematicians of the first rank; but their labours have not been successful in advancing this branch of the science beyond the steps made by the first algebraists.

The rules usually given for the solution of cubic and biquadratic equations are to be found in all the elementary books, and it would be superfluous to repeat them here. An account of the attempts that have been made to obtain a general theory for solving algebraic equations would greatly exceed the limits we must prescribe to ourselves. What has most impeded the progress of algebraists in their researches on this subject, is the difficulty of treating it by a perfect analysis, or of arriving at general conclusions by a process of reasoning founded solely on the principles of the inquiry, and disengaged from particular artifices of calculation, and from particular suppositions. In what follows, we shall endeavour to lay before our readers the general principles on which is founded all that has been successfully accomplished in this theory.

Let the three roots of a cubic equation be represented by a, b, c; and having interchanged these letters among one another, in all possible ways, we shall get the six permutations following, viz.

$$\begin{array}{lll} abc, & cab, & bca, \\ acb, & bac, & cba. \end{array}$$

The combinations that stand first on the left are formed by prefixing the same letter to the permutations made with the other two; and those on each line are derived from one another by making the last letter of one stand first in that which follows, while the other two letters preserve the same order.

Now let $\varrho^3 - 1 = 0$; and let the letters of first combination of each line be prefixed in order to the three terms of $1 + \varrho + \varrho^2$; then we shall get

$$t = a + b\varrho + c\varrho^2, \qquad s = a + c\varrho + b\varrho^2;$$

and if we multiply t and s by $1, \varrho, \varrho^2$ successively, we shall further obtain

$$\begin{array}{ll} t = a + b\varrho + c\varrho^2, & s = a + c\varrho + b\varrho^2, \\ t\varrho = c + a\varrho + b\varrho^2, & s\varrho = b + a\varrho + c\varrho^2, \\ t\varrho^2 = b + c\varrho + a\varrho^2. & s\varrho^2 = c + b\varrho + a\varrho^2. \end{array}$$

The six quantities t, $t\varrho$, $t\varrho^2$, s, $s\varrho$, $s\varrho^2$, comprehend all the values that can be formed by combining with $1 + \varrho + \varrho^2$, the three letters taken in any order whatever; and it is obvious that the cubes of all these six quantities, being each equal either to t^3 or s^3, have no more than two values.

And because t^3 and s^3 have only one value each, any symmetrical functions of them, as $t^3 + s^3$ and $t^3 s^3$, will have determinate values, which remain the same, however the letters a, b, c be interchanged among one another. The quantities $t^3 + s^3$ and $t^3 s^3$ must, therefore, be symmetrical functions of a, b, c; and, consequently, they can be found in terms of the co-efficients of the given equation.

By actually involving to the third power, we get

$$\begin{aligned} t^3 = a^3 + b^3 + c^3 + 6\,abc \\ + 3\,(a^2b + b^2c + c^2a)\,.\,\varrho \\ + 3\,(a^2c + c^2b + b^2a)\,.\,\varrho^2, \\ s^3 = a^3 + b^3 + c^3 + 6\,abc \\ + 3\,(a^2c + c^2b + b^2a)\,.\,\varrho \\ + 3\,(a^2b + b^2c + c^2a)\,.\,\varrho^2. \end{aligned}$$

and likewise

$$\begin{aligned} (a + b + c)^3 = a^3 + b^3 + c^3 + 6\,abc \\ + 3\,(a^2b + b^2c + c^2a) \\ + 3\,(a^2c + c^2b + b^2a). \end{aligned}$$

Now $1 + \varrho + \varrho^2 = 0$, when ϱ is any root of $\varrho^3 - 1 = 0$ different from unit; therefore, by adding the last three expressions, we get

$$\begin{aligned} t^3 + s^3 = 3\,(a^3 + b^3 + c^3) + 18\,abc \\ - (a + b + c)^3. \end{aligned}$$

Again, by actually multiplying

$$\begin{aligned} ts = a^2 + b^2 + c^2 \\ + (ab + bc + ca)\,.\,\varrho \\ + (ab + bc + ca)\,.\,\varrho^2; \end{aligned}$$

and, because $\varrho + \varrho^2 = -1$,

$$\begin{aligned} ts = a^2 + b^2 + c^2 \\ - (ab + bc + ca). \end{aligned}$$

By means of the preceding formulæ, we can compute the values of $t^3 + s^3$ and $t^3 s^3$; and these values being the co-efficients of a quadratic equation having its roots equal to t^3 and s^3, we can thence find t^3 and s^3, and t and s. Now t and s being known, we have

$$\begin{aligned} a + b + c &= a + b + c, \\ t &= a + b\varrho + c\varrho^2, \\ s &= a + c\varrho + b\varrho^2; \end{aligned}$$

wherefore,

$$a = \frac{1}{3}(a + b + c) + \frac{1}{3}(t + s),$$

$$b = \frac{1}{3}(a + b + c) + \frac{1}{3}(t\varrho^2 + s\varrho),$$

$$c = \frac{1}{3}(a + b + c) + \frac{1}{3}(t\varrho + s\varrho^2).$$

To apply the foregoing investigation, we shall take a cubic equation, $x^3 - 3px - 2q = \upsilon$, which is so prepared as to want the second term, then (Sect. 9)

$$\begin{aligned} a + b + c &= 0, \\ ab + ac + bc &= -3p, \\ a^2 + b^2 + c^2 &= 6p, \\ a^3 + b^3 + c^3 &= 6q, \\ abc &= 2q; \end{aligned}$$

consequently $t^3 + s^3 = 3^3 \times 2q$; $ts = 9p$, and $t^3 s^3 = 3^3 \times 3^3\,.\,p^3$. Hence

$$\frac{1}{3}t = (q + \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

$$\frac{1}{3}s = (q - \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

Wherefore, by substituting these values in the expressions of the roots, we get

$$a = (q + \sqrt{q^2 - p^3})^{\frac{1}{3}} + (q - \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

$$b = \varrho^2 \cdot (q + \sqrt{q^2 - p^3})^{\frac{1}{3}} + \varrho\,.\,(q - \sqrt{q^2 - p^3})^{\frac{1}{3}},$$

$$c = \varrho \cdot (q + \sqrt{q^2 - p^3})^{\frac{1}{3}} + \varrho^2 \cdot (q - \sqrt{q^2 - p^3})^{\frac{1}{3}}.$$

The preceding investigation, as well as all other methods that have been proposed for cubic equations, leads to the same result with the rule invented by Cardan; and, like that rule, it becomes in some cases insufficient for arithmetical computation, on account of the imaginary quantities that appear in the expressions of the roots. What is now mentioned is not an accidental circumstance, but a necessary consequence of the method of investigation pursued, and of the introduction of the imaginary roots of the equation $\varrho^3 - 1 = 0$. When a, b, c, are real quantities, the value of t and s will be both imaginary, because they involve ϱ and ϱ^2, or $\frac{-1+\sqrt{-3}}{2}$ and $\frac{-1-\sqrt{-3}}{2}$. In this case, therefore, although the three roots of the proposed equation are all real, yet the algebraic expressions of them are all imaginary, and useless for the purpose of numerical calculation; and the former circumstance is precisely the reason of the latter. On the other hand, when one root a is real and the other two imaginary, the impossible quantities destroy one another in the expressions of t and s, which are, therefore, real quantities; and in this case the algebraic formulæ answer for finding the numerical values of the roots. The distinction here pointed out depends on the radical $\sqrt{q^2 - p^3}$, which is real or imaginary, according as the equation has one or three real roots, because $q^2 - p^3$ is always positive in the first case and negative in the second.

Much labour and thought have been bestowed in order to free the formulæ for the roots of cubic equations from the imaginary expressions that render them unfit for arithmetical computation. In particular instances the difficulty disappears; namely, when the radical quantities are perfect cubes, in which cases the impossible parts of the cube roots destroy one another, so as to leave none but real quantities in the expressions of the roots of the equation. And, by expanding the radical quantities, we may in all cases obtain the roots of a cubic equation in series of an infinite number of terms free from the imaginary sign. But when it is required to transform the formulæ for the case of a cubic equation with three real roots, into finite expressions free from impossible quantities, and to do so without employing any other than the received notations of algebra, all attempts to solve the problem have led to equations in the same circumstances with the one proposed, and have ended in bringing back the same difficulty; in so much that equations of the description mentioned are said to be in the irreducible case.

It is, however, possible to transform the formulæ for the roots of a cubic equation in the irreducible case into real expressions, although not so as to fulfil all the conditions above mentioned. Let $q^2 - p^3 = y^2$; then $p = (q^2 - y^2)^{\frac{1}{3}}$: wherefore the equation $x^3 - 3px - 2q = 0$, will become

$$x^3 - 3\,(q^2 - y^2)^{\frac{1}{3}}\,x - 2q = 0 \ldots (1).$$

By the preceding formula the value of x in this equation will be

$$x = (q + y)^{\frac{1}{3}} + (q - y)^{\frac{1}{3}};$$

or, according to the notation of Section 10, making

$$n = \frac{1}{3},$$

$$x = 2\mathrm{H}_{\frac{1}{3}}\,(q, y^2).$$

By substituting this value of x, we get

$$\left\{2\mathrm{H}_{\frac{1}{3}}(q, y^2)\right\}^3 - 3(q^2 - y^2)^{\frac{1}{3}} . \left\{2\mathrm{H}_{\frac{1}{3}}(q, y^2)\right\} - 2q = 0;$$

which equation, being true for all values of q and y^2, must be identical, or, when expanded, must consist of a series of quantities that mutually destroy one another. Now the equation will still be identical, when y^2 is changed into $-y^2$; so that we shall have

$$\left\{2\mathrm{H}_{\frac{1}{3}}(q, -y^2)\right\}^3 - 3(q^2 + y^2) . ^{\frac{1}{3}} \left\{2\mathrm{H}_{\frac{1}{3}}(q, -y^2)\right\} - 2q = 0;$$

and this proves that the equation

$$x^3 - 3\,(q^2 + y^2)^{\frac{1}{3}} . x - 2q = 0 \ldots (2)$$

is solved by the formula

$$x = 2\mathrm{H}_{\frac{1}{3}}\,(q, -y^2).$$

As the investigation in Section 10 is equally true, whether n be a whole or a fractional number, we may apply it to find the value of the symbol $2\mathrm{H}_{\frac{1}{3}}\,(q, -y^2)$.

For this purpose, let
$q = r \cos. \varphi = r \cos. (\varphi + 360°) = r \cos. (\varphi + 2 . 360°)$,
$y = r \sin. \varphi = r \sin. (\varphi + 360°) = r \sin. (\varphi + 2 . 360°)$;
then $r = \sqrt{q^2 + y^2}$; and, according as we take one or other of the angles that have the same sines and cosines, we shall obtain three different values of $2\mathrm{H}_{\frac{1}{3}}\,(q, -y^2)$, or of x, viz.:

$$a = 2r^{\frac{1}{3}} . \cos. \frac{\varphi}{3},$$

$$b = 2r^{\frac{1}{3}} . \cos. \left(\frac{\varphi}{3} + 120°\right),$$

$$c = 2r^{\frac{1}{3}} . \cos. \left(\frac{\varphi}{3} + 240°\right).$$

By putting $p = (q^2 + y^2)^{\frac{1}{3}}$, the equation (2) will assume the same form as at first, namely,

$$x^3 - 3px - 2q = 0;$$

and because $p^3 = q^2 + y^2 = r^2$, and $y = \sqrt{p^3 - q^2}$, if we determine the angles by means of their tangents instead of their sines and cosines, we shall get $\frac{\sqrt{p - q^2}}{q} = \tan. \varphi = \tan. (\varphi + 360°) = \tan. (\varphi + 2 . 360°)$; and the three roots of the equation will be

$$a = 2\sqrt{p} . \cos. . \frac{\varphi}{3},$$

$$b = 2\sqrt{p} . \cos. \left(\frac{\varphi}{3} + 120°\right),$$

$$c = 2\sqrt{p} . \cos. \left(\frac{\varphi}{3} + 240°\right).$$

Every cubic equation falls under one or other of the formulæ (1) and (2), except when $y = 0$, or $p^3 = q^2$, which takes place when an equation changes from one class to another; and in this case we have

$$x^3 - 3q^{\frac{2}{3}} . x - 2q = (x - 2\,q^{\frac{1}{3}}) . (x + q^{\frac{1}{3}}) . (x + q^{\frac{1}{3}}).$$

The several rules that have now been given, therefore, include every possible case.

The difficulty attending the irreducible case arises from a real distinction between the two subordinate classes of cubic equations, and is insurmountable by the ordinary operations of algebra. There is no permanent distinctions of equations belonging to the same order, when we consider their roots as positive or negative; because, in any proposed equation, all the roots, or as many of them as we please, can be changed from positive to negative, by the simple artifice of increasing or diminishing them all by a given quantity. But the case is otherwise when we consider the roots of an equation in their character of real or imaginary quantities. No transformation can change an equation with one real root into another with three real roots, without involving the operations of the impossible arithmetic. If, therefore, we lay down this condition, namely, that the formulæ for the roots of equations must be in a shape fit for numerical calculation, we may conclude that in fact there is no resolution of equations except what consists in reducing all those of the same class to some one of that class, the most simple and convenient in its form that can be found. If we examine the preceding investigation, it will appear that it is merely an attempt to reduce all cubic equations to the form $x^3 - A = 0$; and this readily succeeds without impossible operations, when the proposed equation, and that with which it is compared, have their roots of a similar description; and it as surely fails when the case is otherwise.

In geometry, where the relations of the magnitudes under consideration are never lost sight of, there is no tendency to refer the solution of a problem to a class to which it does not belong. The ancient geometer could never be in danger of applying the problem for finding two mean proportionals to a case that can be constructed only by the trisection of an angle. The modern analyst, dismissing the original magnitudes of his problem, and reducing all possible relations to equations in abstract numbers, is apt to overlook distinctions, and sometimes to waste his labour, in seeking to accomplish what a due separation of cases would show to be impossible. There is the same distinction between the class of cubic equations with one real root, and that with three real roots, that there is between the two geometrical problems alluded to above; and the algebraist who attempts, by means of the ordinary operations of his art, to transform Cardan's formula so as to make it apply to the irreducible case, is precisely in the same situation with the geometer who should set about trisecting an angle by finding two mean proportionals.

The power and force of the algebraic method does not consist in breaking down real distinctions, but in connecting, by sure and general principles, many truths which in geometry are joined only by vague analogies, and even have no affinity at all. This advantage is derived chiefly from the doctrine of negative quantities, and from the impossible arithmetic. By means of the first, a formula which is obtained by considering only one state of the data of a problem, applies, necessarily and by the very structure of analytical language, to the same problem in all possible conditions of the data. On the other hand, when the relations of the data vary, the geometer is obliged to subdivide his problem into cases, or into other subordinate problems; and although it may be perceived that great similitude prevails among all the subdivisions, yet it is impossible to reduce the analogy between them to determinate rules, as is done in algebra. But in the whole compass of geometry there is nothing that bears any resemblance to the imaginary arithmetic. When the geometer has fixed the *determination* of his problem, or ascertained the limits within which it is possible, he has drawn a line that must be the boundary of his investigation. Now it is to truths lying beyond this line that the meaning of the comprehensive expressions of the imaginary arithmetic must be referred. It is not to be understood that a problem can be solved by algebra, which is impossible in geometry; but the analytical formulæ, at the same time that they mark the limits of the problem, go beyond them, and point out connected truths, that require only certain changes to be made in the algebraic expressions, in like manner as all the possible cases of the same problem are derived from one only, by means of the variations of the signs.

Biquadratic equations.

If a, b, c, d, represent the four roots of a biquadratic equation; and if we prefix the same letter a to all the permutations made with the other three, we shall get the six combinations following, viz.

$$abcd,\quad adbc,\quad acdb,$$
$$adcb,\quad acbd,\quad abdc.$$

In the first line, the letters b, c, d, are made to circulate, by placing immediately after the immoveable letter a that which stands last in the combination preceding; and in the second line the moveable letters have respectively an inverted order to what they have in the first line.

Let $\varrho^2 - 1 = 0$; and let the four letters taken in the several orders of the six combinations be prefixed to the terms of $1 + \varrho + \varrho^2 + \varrho^3$; the results of the first line being t, t', t'', and those of the second line s, s', s''; then

$$\begin{aligned} t &= a + b\varrho + c\varrho^2 + d\varrho^3, & s &= a + d\varrho + c\varrho^2 + b\varrho^3, \\ t' &= a + d\varrho + b\varrho^2 + c\varrho^3, & s' &= a + c\varrho + b\varrho^2 + d\varrho^3, \\ t'' &= a + c\varrho + d\varrho^2 + b\varrho^3, & s'' &= a + b\varrho + d\varrho^2 + c\varrho^3. \end{aligned}$$

Now, in the equation $\varrho^2 - 1 = 0$, ϱ is either equal to $+1$ or to -1; and whether we take the one value or the other, it is apparent that $t = s$, $t' = s'$, $t'' = s''$.

Again, from every one of the six foregoing combinations, four others are derived by circulating the letters continually from the last place to the first; and in this manner we obtain twenty-four permutations, which are all that can be made with four letters. Thus, if we take $abcd$, and move the letters as directed, we shall get these four combinations, viz.

$$\begin{gathered} abcd, \\ dabc, \\ cdab, \\ bcda. \end{gathered}$$

And if we multiply t by ϱ continually, observing to retain the three first powers of ϱ, and to make $\varrho^4 = 1$, we shall get

$$\begin{aligned} t &= a + b\varrho + c\varrho^2 + d\varrho^3, \\ t\varrho &= d + a\varrho + b\varrho^2 + c\varrho^3, \\ t\varrho^2 &= c + d\varrho + a\varrho^2 + b\varrho^3, \\ t\varrho^3 &= b + c\varrho + d\varrho^2 + a\varrho^3; \end{aligned}$$

so that t, $t\varrho$, $t\varrho^2$, $t\varrho^3$, are the functions formed by prefixing to $1 + \varrho + \varrho^2 + \varrho^3$, the letters of the four combinations; and it is obvious that these functions have all the same square, equal to t^2.

Wherefore, if the four letters, taken in all possible orders, be prefixed to the terms of $1 + \varrho + \varrho^2 + \varrho^3$, the squares of the twenty-four resulting functions will be equal to one or other of the six quantities, t^2, t'^2, t''^2, s^2, s'^2, s''^2; and since it has been proved that $t = s$, $t' = s'$, $t'' = s''$, it follows that the twenty-four squares have no more than three different values, equal to t^2, t'^2, t''^2.

And because t^2, t'^2, t''^2, can have no more than one value each, any symmetrical functions of them, viz.

$$\begin{gathered} t^2 + t'^2 + t''^2, \\ t^2t'^2 + t^2t''^2 + t'^2t''^2, \\ t^2t'^2t''^2, \end{gathered}$$

will have determinate values independent of the order of the letters a, b, c, d. The same functions will therefore be symmetrical expressions of the roots of the given biquadratic equation, and they will be known in terms of the co-efficients of that equation.

Supposing $\varrho = -1$, we get

$$\begin{aligned} t &= a - b + c - d, \\ t' &= a - d + b - c, \\ t'' &= a - c + d - b; \end{aligned}$$

and hence

$$\begin{aligned} t^2 &= a^2 + b^2 + c^2 + d^2 \\ &\quad - 2(ab + ad + bc + cd) + 2(ac + bd), \\ &= (a + b + c + d)^2 - 4\Sigma . ab + 4(ac + bd) \cdot, \end{aligned}$$

the symbol $\Sigma\,.\,ab$ being used here, as in Sect. 9, to denote the sum of the products of every two of the roots. Wherefore, if we put

$$\begin{aligned} M &= (a+b+c+d)^2 - 4\Sigma\,.\,ab, \\ m &= ac+bd, \\ m' &= ab+dc, \\ m'' &= ad+bc, \end{aligned}$$

then

$$\begin{aligned} t^2 &= M+4m, \\ t'^2 &= M+4m', \\ t''^2 &= M+4m''; \end{aligned}$$

and hence

$$\begin{aligned} t^2+t'^2+t''^2 &= 3M+4(m+m'+m''), \\ t^2t'^2+t^2t''^2+t'^2t'''^2 &= 3M^2+\ 8M(m+m'+m'') \\ &\quad +16(mm'+mm''+m'm''). \end{aligned}$$

But it will readily appear that

$$\begin{aligned} m+m'+m'' &= \Sigma\,.\,ab \\ mm'+mm''+m'm'' &= (a+b+c+d)\times\Sigma\,.\,abc \\ &\quad - 4abcd. \end{aligned}$$

Now, by substituting these values, we get

$$\begin{aligned} t^2+t'^2+t''^2 &= 3(a+b+c+d)^2 - 8\Sigma\,.\,ab, \\ t^2t'^2+t^2t''^2+t'^2t''^2 &= 3(a+b+c+d)^4 - 16(a+b+c \\ &\quad +d)^2\times\Sigma\,.\,ab \\ &\quad +16(a+b+c+d)\times\Sigma\,.\,abc + 16(\Sigma\,.\,ab)^2 \\ &\quad - 64abcd. \end{aligned}$$

Again, if we multiply the expressions of t, t', t'', we shall get

$$\begin{aligned} tt't't'' &= (a-c)\,.\,(a^2-c^2)+(b-d)\,.\,(b^2-d^2) \\ &\quad -(a+c)\,(b-d)^2-(b+d)\,(a-c)^2; \end{aligned}$$

or,

$$\begin{aligned} tt't'' &= a^3+b^3+c^3+d^3+2\Sigma\,.\,abc \\ &\quad -(a^2b+a^2c+a^2d+b^2a+b^2c+b^2d \\ &\quad +c^2a+c^2b+c^2d+d^2a+d^2b+d^2c); \end{aligned}$$

and finally, by means of the formulæ in Sect. 9,

$$\begin{aligned} tt't'' &= (a+b+c+d)^3+8\Sigma\,.\,abc \\ &\quad -4(a+b+c+d)\times\Sigma\,.\,ab. \end{aligned}$$

If now we substitute the values computed by the preceding formulæ in the cubic equation

$$\begin{aligned} 0 = u^3 &- (t^2+t'^2+t''^2)u^2 \\ &+ (t^2t'^2+t^2t''^2+t'^2t''^2)u \\ &- t^2t'^2t''^2, \end{aligned}$$

we shall obtain the values of t^2, t'^2, t''^2, and consequently of t, t', t'', by solving that equation; and when t, t', t'', are known, we have

$$\begin{aligned} a+b+c+d &= a+b+c+d, \\ t &= a+b\varrho+c\varrho^2+d\varrho^3, \\ t' &= a+d\varrho+b\varrho^2+c\varrho^3, \\ t'' &= a+c\varrho+d\varrho^2+b\varrho^3; \end{aligned}$$

wherefore, because $0=1+\varrho+\varrho^2+\varrho^3$, we get

$$a=\frac{1}{4}\left\{a+b+c+d+t+t'+t''\right\},$$

$$b=\frac{1}{4}\left\{a+b+c+d+t\varrho^3+t'\varrho^2+t''\varrho\right\},$$

$$c=\frac{1}{4}\left\{a+b+c+d+t\varrho^2+t'\varrho+t''\varrho^3\right\},$$

$$d=\frac{1}{4}\left\{a+b+c+d+t\varrho+t'\varrho^3+t''\varrho^2\right\}.$$

And finally, by making $\varrho=-1$,

$$a=\frac{1}{4}\left\{a+b+c+d+t+t'+t''\right\},$$

$$b=\frac{1}{4}\left\{a+b+c+d-t+t'-t''\right\},$$

$$c=\frac{1}{4}\left\{a+b+c+d+t-t'-t''\right\},$$

$$d=\frac{1}{4}\left\{a+b+c+d-t-t'+t''\right\}.$$

In applying these formulæ, it is necessary to observe, that as the quantities t, t', t'', are found by extracting the square root, they may each have either the sign plus or the sign minus prefixed. But all ambiguity from this cause will be taken away, if it be observed that the expressions of a, b, c, d, will always give the same results, provided the signs of t, t', t'', be so determined as to satisfy the equation,

$$\begin{aligned} tt't'' &= (a+b+c+d)^3+8\Sigma\,.\,abc \\ &\quad -4(a+b+c+d)\times\Sigma\,.\,ab. \end{aligned}$$

For, if we suppose that the signs of t, t', t'', are so determined as to satisfy the equation mentioned, they cannot be varied so as still to satisfy the same equation, unless two of them be changed together; for, if one sign only be changed, or if all the three be changed together, the product $tt't''$ will have an opposite sign to what it had before, and the equation will no longer be satisfied. But the expressions of a, b, c, d, give the same set of values when the signs of any two of the letters t, t', t'', are changed together; so that, in order to have the true values of the quantities sought, no other rule for the signs of t, t', t'', is necessary than that they must be such as to satisfy the equations alluded to.

To apply the preceding investigation, we may take the equation

$$x^4+px^2+qx+r=0,$$

which wants the second term. Then,

$$\begin{aligned} o &= a+b+c+d, \\ p &= \Sigma\cdot ab, \\ -q &= \Sigma\,.\,abc, \\ r &= abcd: \end{aligned}$$

hence

$$\begin{aligned} t^2+t'^2+t''^2 &= -8p, \\ t^2t'^2+t^2t''^2+t'^2t''^2 &= 16p^2-64r, \\ tt't'' &= 8q: \end{aligned}$$

and t^2, t'^2, t''^2, are the roots of the cubic equation

$$u^3+8pu^2+16(p^2-4r)u-64q^2=0.$$

Having solved this equation, and found the values of t, t', t'', the signs of these quantities must next be determined so as to satisfy the equation,

$$tt't''=-8q;$$

and then we have these formulæ for computing the roots of the proposed equation, viz.

$$a=\frac{t+t'+t''}{4},$$

$$b=\frac{-t+t'-t''}{4},$$

$$c=\frac{t-t'-t''}{4},$$

$$d=\frac{-t-t'+t''}{4}.$$

These formulæ coincide with the method of solving biquadratic equations first proposed by Euler in his Algebra. But, in order to take away the ambiguity arising from the double sign of the square root, that celebrated mathematician uses two sets of expressions for the roots of the equation, viz.

$$\begin{aligned} a &= \frac{t+t'+t''}{4}, & a &= \frac{-t-t'-t''}{4}, \\ b &= \frac{-t+t'-t''}{4}, & b &= \frac{t-t'+t''}{4}, \\ c &= \frac{t-t'-t''}{4}, & c &= \frac{-t+t'+t''}{4}, \\ d &= \frac{-t-t'+t''}{4}, & d &= \frac{t+t'-t''}{4}, \end{aligned}$$

of which one set is the same with the formulæ given above, and the other is obtained by changing t, t', t'', into $-t$, $-t'$, $-t''$; the first set being directed to be used when $-8q$ is positive, and the other set when the same quantity is negative. This procedure is not so simple as that we have followed, which requires only one set of formulæ. It has even been the occasion of leading into error, in as much as it makes the signs of t, t', t'', depend entirely upon the sign of the given quantity $-8q$; whereas it is indispensable that, regard being had to the nature of the quantities t, t', t'', their signs shall be determined so as to satisfy the equation $tt't''=-8q$. This inadvertence of Euler has escaped the observation of most of the authors who have treated of biquadratic equations, and was first noticed by M. Bret, in the second volume of the *Correspondance sur l'Ecole Polytechnique.*

It may not be improper to notice briefly some of the other rules for biquadratic equations. These are chiefly two; the method of Descartes, which resolves the given equation into two quadratic factors; and the oldest method of all, invented by Louis Ferrari, a pupil of Cardan, which proceeds by transforming the given equation, so as to make it equal to the difference of two complete squares, and then extracting the square roots. However different from one another these two methods may at first seem, they are at bottom the same; and they are so far connected with that already investigated, that all the three lead to the same cubic equation.

Suppose that a, b, c, d, are the roots of the biquadratic equation

$$x^4-Ax^3+Bx^2-Cx+D=0;$$

then $x^2-(a+b)\,x+ab=0$, and $x^2-(c+d)\,x+cd=0$, are two quadratic factors, the product of which is equal to the given equation. Now,

$$A=a+b+c+d,$$
$$t=a+b-c-d;$$

wherefore, if we put $ab=p+y$, $cd=p-y$, the two factors will become

$$x^2-\frac{1}{2}(A+t)\,x+p+y=0,$$

$$x^2-\frac{1}{2}(A-t)\,x+p-y=0:$$

and if we multiply them, and equate the co-efficients of the product to the co-efficients of the given equation, we shall get

$$2p+\frac{1}{4}A^2-\frac{1}{4}t^2=B,$$
$$Ap+ty=C,$$
$$p^2-y^2=D.$$

And it is to be observed that, on account of the first two of these equations, p and y are both real quantities when t is a real quantity; so that, provided a real value of t can be found, the given equation is always resolved, by this method, into two quadratic factors free from imaginary expressions.

Now, by combining the equations just found, we shall get

$$\begin{aligned}0=t^6&-(3A^2-8B)\cdot t^4\\&+(3A^4-16A^2B+16B^2+16AC-64D)\cdot t^2\\&-(A^3-4AB+8C)^2,\end{aligned}$$

$$p=\frac{1}{2}B-\frac{1}{8}A^2+\frac{1}{8}t^2$$

$$y=\sqrt{\left(\frac{1}{2}B-\frac{1}{8}A^2+\frac{1}{8}t^2\right)^2-D}.$$

The first of these equations is a cubic, of which the root is t^2; and it is precisely the same with the cubic of the former method. As the last term of this equation is essentially positive, it follows that there is always one positive value of t^2, and one real value of t; wherefore, in consequence of what has been proved, the values of p and y, derived from the positive value of t^2, are in every case real quantities, which is no doubt an advantage in the practical application of the method.

If we wish to follow the process of Louis Ferrari, we may assume p, t, y, so as to render the expression

$$\left(x^2-\frac{1}{2}Ax+p\right)^2-\left(\frac{1}{2}tx+y\right)^2=0$$

identical with the given equation; and as this expression is no more than the product of the two quadratic factors of the last method, the quantities to be determined will be found by the formulæ already given.

Equations of the fifth degree.

The theory of permutations, which is successful in solving cubic and biquadratic equations, applies likewise to those of the fifth and higher orders. But, to use the words of Lagrange, "Passé le quatrième degré, la méthode, quoiqu' applicable en général, ne conduit plus qu'à des equations resolvantes de degres superieurs à celui de la proposée." Thus, in the case of equations of the fifth degree, the theory leads to a biquadratic equation, of which the co-efficients are to be found by resolving an equation of the sixth order.

There is, however, no doubt that the doctrine of permutations contains the principles from which we are to expect the resolution of equations of the higher orders, if the problem be possible. It may be alleged, with great probability, that the theory succeeds in the less complicated cases, because when the number of the roots is small, their permutations are soon exhausted, and we speedily arrive at those combinations of them which remain invariable, whatever be the order of the quantities combined. But when the number of the roots is greater than four, their permutations are very numerous, and at the same time the functions produced by combining them are very complicated; on which accounts it is difficult to conduct the investigation so as to arrive at a satisfactory conclusion, either accomplishing the intended purpose, or proving that the undertaking is impossible.

In the twelfth volume of the *Italian Society*, and in a work published at Modena in 1813, M. Paolo Ruffini has proved that no function of five letters can exist that is susceptible of only three or four different values when the letters are interchanged among one another in all possible ways. M. Cauchy, in the sixteenth volume of the *Journal de l'Ecole Polytechnique*, has demonstrated that a function of n letters, unless it have no more than two different values, cannot have a number of different values less than the prime number next below n. On these grounds it has been inferred that the resolution of equations of the fifth degree is in reality an impossible problem. (Lacroix, *Compt. des Elem. d'Algebre*, p. 61.) And if it be admitted that, in the process of resolution, no equations can occur except such as have symmetrical functions of the five letters for their co-efficients, the inference founded on the labours of the eminent mathematicians we have mentioned would be indisputable. But it is not impossible that the resolution of equations of a high order must be effected by gradually depressing an equation at first of great dimensions; and in this procedure we may arrive at equations, the co-efficients of which, although functions of the roots of the proposed equation, are not symmetrical functions, but partial expressions, susceptible of several values, according as the order of the letters that denote the roots is made to vary. On this supposition, the resolution of equations above the fourth order, by means of equations inferior in degree, would not be inconsistent with what has been proved.

Some particular classes of equations.

17. A method for solving equations of one order may be generalized so as to extend to a certain class in all orders. Thus De Moivre has found a species of equations

of every degree that have their roots similar to those of cubics, and which are solved by the formula

$$x = (q + \sqrt{q^2 - p^n})^{\frac{1}{n}} + (q - \sqrt{q^2 - p^n})^{\frac{1}{n}},$$

differing in no respect from the expression for resolving cubics, except that n is written in place of 3.

An equation may be depressed to a lower order when it is known that the roots have a given relation to one another. An instance of this has already occurred in the case of equal roots; for, the equal roots having been first found, the equation can be lowered by division. Reciprocal equations furnish another example of depression to a lower order, on account of a relation subsisting among the roots. A reciprocal equation is one of even dimensions, such that half the roots are respectively the reciprocals of the other half, in which case no alteration is produced in the equation when $\frac{1}{x}$ is substituted for x. In equations of this kind, the same co-efficients occur in the same order, and with the same signs, reckoning from either end; a description that likewise applies to some equations of odd dimensions, which, however, do not constitute a new class, being merely reciprocal equations, as defined above, multiplied by the factor $x + 1$. A reciprocal equation may always be depressed to half the dimensions, by transforming it so that the new unknown quantity shall be equal to $x + \frac{1}{x}$. It is sufficient to have mentioned these cases, which are fully treated of in all the elementary books.

Equations with only two terms, as $x^p - 1 = 0$, are the most extensive class that have been resolved by a general method. The successful application of analysis to this class of equations is extremely interesting, both in itself, and likewise because it is connected with the division of the circle into equal parts, and has occasioned the discovery of some curious and unexpected results respecting that problem. For these reasons, it appears proper to lay before our readers a short view of this branch of the doctrine of algebraic equations.

We have already shown, that, admitting the theory of angular sections, every equation with only two terms, as $x^p - 1 = 0$, may be completely resolved into its binomial and trinomial factors; and hence all its roots, possible and impossible, may be computed by means of the trigonometrical tables in common use. If we put $\varphi = \frac{360^\circ}{p}$, and denote by k any number less than $\frac{1}{2}p$, we have found that the equation $x^p - 1 = 0$ is divisible by the quadratic factor $x^2 - 2x, \cos. \varphi + 1$, and, consequently, that it has the two impossible roots,

$$x = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$
$$x = \cos. k\varphi - \sin. k\varphi . \sqrt{-1}:$$

and, because $\cos. k\varphi = \cos. (p - k)\varphi$, and $-\sin. k\varphi = \sin. (p - k)\varphi$, the same two roots may be otherwise more symmetrically represented thus,

$$x = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$
$$x = \cos. (p-k)\varphi + \sin. (p-k)\varphi . \sqrt{-1}.$$

Therefore, when p is odd, the equation $x^p - 1 = 0$ has one real root equal to 1; and when p is even, it has two real roots equal to ± 1; and in both cases the remaining roots are all impossible, and are found from the formula

$$x = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$

by making k equal to all the integral numbers less than p in the one case, and less than $p - 1$ in the other. Nothing, therefore, can be more simple than the computation of the roots of such equations by means of the trigonometrical tables. But in seeking a general solution, it is required to investigate the roots without resorting to the properties of the circle, unless in so far as this may be necessary for solving similar equations inferior in degree to the one proposed. In this view the resolution of the equation $x^p - 1 = 0$, is equivalent to the division of the circle into p equal parts, granting the like division for all numbers less than p. And in order to render the investigation of the problem as simple as possible, it may be further observed, that it will be sufficient to consider the case when the exponent is a prime number; because, from this case, the other, when it is a composite number, can be readily deduced.

It will be proper to premise here a property of the roots of equations with only two terms, to which we shall have occasion continually to refer. The property in question depends upon this theorem, namely, when k is any number not a multiple of the prime number p, the remainders of the terms of the series

$$1 \times k, 2 \times k, 3 \times k \ldots (p-1) \times k,$$

when each is divided by p, are all different from one another; and, consequently, without regard to the order, they will coincide with the numbers 1, 2, 3, &c. less than p. If, therefore, we take any one of the impossible roots of the equation x^{p-1}, viz.

$$r = \cos. k\varphi + \sin. k\varphi \sqrt{-1},$$

all its powers with indices less than p, viz.

$$r^2 = \cos. 2k\varphi + \sin. 2k\varphi . \sqrt{-1},$$
$$r^3 = \cos. 3k\varphi + \sin. 3k\varphi . \sqrt{-1},$$
&c.

will be different from one another; and likewise they will coincide, without regard to the order, with the like powers of any other impossible root of the same equation: because, whatever number k stands for, the arcs are all different from one another, and, neglecting whole circumferences, constitute the same series of terms, although in different orders. Wherefore, p being a prime number, if r be one of the impossible roots of the equation $x^p - 1 = 0$, all the roots will be represented by the terms of the geometrical progression

$$r^0, r^1, r^2, r^3, \ldots . r^{p-1};$$

for every one of these terms satisfies the given equation, and it has been shown that they are all different from one another.

When p is a composite number, the same property does not belong to all the roots of the equation $x^p - 1 = 0$, but only to some of them. It belongs generally to the root

$$r = \cos. k\varphi + \sin. k\varphi . \sqrt{-1},$$

when k is either equal to unit, or to any number that has no common divisor with p; in which cases all the powers of r are roots of the equation $x^p - 1 = 0$, and all different from one another, when the exponents are different and less than p.

If the equation $x^p - 1 = 0$ be divided by the binomial factor $x - 1$, we shall get

$$x^{p-1} + x^{p-2} + x^{p-3} \ldots + x + 1 = 0;$$

and this being a reciprocal equation, it can be farther depressed to half the dimensions. In this manner we obtain the solution of $x^7 - 1 = 0$, which is reduced to a cubic; but, by the same procedure, the equation next in order, viz. $x^{11} - 1 = 0$, can be lowered only to the fifth degree, for equations of which class there is no rule. Nevertheless this last equation has been solved by Vandermonde, to whom, and to Lagrange, we are mainly indebted for disengaging the resolution of equations from the complicated operations of algebra, and for substituting, in their place, reasonings founded on the doctrine of combinations. The author has not explained particularly the process by which his solution was obtained; he gives it as a result of his theory, which, although it fails in general for equations above the fourth degree, succeeds in this instance on account of particular relations between the roots. Similar relations subsist between the roots of any other binomial equation when the exponent is a prime number; and, in consequence, a like mode of investigation will apply, as indeed the author has expressly said. But this procedure would unavoidably be attended in every new instance with very long calculations; and it appears hardly possible to arrive in this way at any general method that would apply to all equations of the class in a regular manner, and without considerations drawn from each particular case.

M. Gauss, in a work entitled *Disquisitiones Arithmeticæ*, replete with original and important matter, applied a property of prime numbers to the solution of binomial equations, which removed every difficulty, and led to a theory that unites simplicity and generality. If we suppose that p is a prime number, and resolve $p - 1$ into its component factors, so that $p - 1 = a^{\lambda} . b^{\mu} . c^{\gamma}$. &c., a, b, c, &c. being prime numbers, M. Gauss has proved that the solution of the equation $x^p - 1 = 0$, or, which is the same thing, the division of the circle into p equal parts, can be effected by solving successively λ equations of a dimensions, μ equations of b dimensions, γ equations of c dimensions, &c. Thus, if $p = 13$, then, because $13 - 1 = 3 \times 2^2$, the roots of $x^{13} - 1 = 0$ can be found, or a polygon of 13 sides can be inscribed in a circle, by solving a cubic and two quadratic equations in succession. In certain cases, when a prime number comes under the form $2^n + 1$, as 17, 257, &c. the division of the circle will require the solution of equations no higher than the second order; whence this unexpected consequence has resulted from the theory of M. Gauss, that the inscription of a polygon of 17, or 257 sides in a circle, which are problems that have always been understood to transcend the limits of the elementary geometry, can, nevertheless, be constructed by the operations admitted in that science.

A work replete with so many interesting discoveries as the *Disquisitiones Arithmeticæ* could not fail to excite the attention of mathematicians. Legendre, in republishing his *Essay on the Theory of Numbers*, has added to it an exposition of M. Gauss's theory of binomial equations; and the same theory is the subject of the 14th note in the second edition of Lagrange's *Treatise on Numerical Equations.* No part of the mathematics could pass through the hands of men of so much ability without receiving great improvement. Lagrange has shown that it is not necessary to go through the several intermediate equations that make so essential a part in the investigation of M. Gauss; and, by this means, he has reduced the solution of equations with two terms to the utmost simplicity of which it is capable. But, in one respect, it must be admitted that the procedure of the illustrious geometer is imperfect. Although it arrives, by a short investigation, at the partial quantities that by their additions form the expressions of the roots sought, it leaves indeterminate the order in which they are to be combined. M. Gauss has avoided ambiguity in this respect by deducing from one of the quantities all the other parts of the same expression; but, amidst a multiplicity of different systems of values that may be deduced from the partial quantities, Lagrange has given no clue to guide to the true one.

In laying before our reader some account of this interesting branch of the theory of algebraic equations, we shall view the subject in a light somewhat different from that in which it has hitherto been placed. Instead of seeking directly the roots of binomial equations, we shall apply the principles of M. Gauss's theory immediately to the division of the circle into equal parts, by taking the arcs of the circumference in that order to which the method owes all its success. This procedure is attended with some advantages. In the first place, the algebraic expressions of the quantities sought, represented by $\cos. \frac{k \times 360°}{p}$, are more simple than those of the imaginary roots of the corresponding binomial equation; and, in the second place, the same expressions, having always real values, are better fitted for application than the roots of binomial equations, which require to be further reduced to prepare them for calculation.

Before entering on the principal problem, it is necessary to say something of that property of numbers on which the whole theory depends. Supposing p to be any prime number, Euler has distinguished by the name of a *Primitive Root* any number less than $p - 1$, such that, if we take the series of all its powers with indices less than p, and in each power reject the multiples of p it contains, the several remainders are all different from one another, and, consequently, paying no regard to the order, they will coincide with the numbers 1, 2, 3, &c. less than p. It has been proved that, for every prime number, there are as many primitive roots as there are numbers less than $p - 1$, which have no common divisor with it. The existence of such numbers in every case is therefore demonstrated; but no direct method of finding them has yet been published with which we are acquainted.

We gladly seize the present occasion of laying down a rule for finding the primitive roots of a prime number. But first we must premise, that when any proposed number is said to satisfy the equation $x^m + 1 = 0$, it is always understood that the multiples of the prime number p are rejected; and the meaning is, that, when the given number is substituted for x, the whole result is divisible by p without any remainder.

Now, let p be a prime number, and 2, a, b, c, &c. the prime divisors of $p - 1$, so that $p - 1 = 2^{\pi} . a^{\lambda} . b^{\mu} . c^{\gamma}$. &c.: then every primitive root will satisfy the first of the following equations without satisfying any of the rest, viz.

$$x^{\frac{p-1}{2}} + 1 = 0,$$

$$x^{\frac{p-1}{2a}} + 1 = 0,$$

$$x^{\frac{p-1}{2b}} + 1 = 0,$$

$$x^{\frac{p-1}{2c}} + 1 = 0,$$

&c.

And, on the other hand, every number not a primitive root, which satisfies the first equation, will at the same time satisfy one, or more, or all, of the other equations.

But the numbers which satisfy the first equation are exclusively those which are not found among the remainders of the series of square numbers divided by p.

Wherefore, setting aside the first equation, if we seek among the non-residual numbers for such as satisfy none of the remaining equations, the numbers so found will be the primitive roots sought.

When one primitive root is found by this method, all the rest may be directly obtained from it. For, if 1, w, w', w'', &c. . . . $n^{(n)}$, represent all the numbers less than $p - 1$ and prime to it; then a being one of the primitive roots, all the roots will be equal to the series of powers,

$$a, a^w, a^{w'}, a^{w''}, \ldots\ldots a^{w^{(n)}},$$

rejecting always the multiples of p.

The demonstration of these properties would lead us aside from our present purpose; and we shall be content with adding some examples for the sake of illustration.

Let $p = 11$: then $\frac{p - 1}{2} = 5$, and $\frac{p - 1}{2 . 5} = 1$; so that in this case, the only equation of exclusion is $x + 1 = 0$, which admits only one solution, viz. $x = p - 1 = 10$. Therefore all the non-residual numbers except 10 are the primitive roots; namely, 2, 6, 7, 8. We may extend this conclusion to every case when $\frac{p - 1}{2}$ is a prime number, as 7, 23, 47, &c.; in all which instances all the non-residuals, except $p - 1$, are the primitive roots.

Next, let $p = 17$; then $\frac{p - 1}{2} = 8 = 2^3$; and there are no equations of exclusion. In this case, therefore, all the non-residuals, without exception, are primitive roots; and the same thing is true of every prime number of the form $2^n + 1$, such as 5, 257, &c.

Let $p = 13$; then $\frac{p - 1}{2} = 2 \times 3$; and the only equation of exclusion is

$$x^2 + 1 = 0,$$

which admits only two solutions, viz. $x = 5$ and $x = 8$. In this instance, therefore, all the non-residual numbers, except 5 and 8, are the primitive roots.

Let $p = 31$; then $\frac{p - 1}{2} = 3 \times 5$; and we have two equations of exclusion, viz.

$$x^3 + 1 = 0,$$
$$x^5 + 1 = 0.$$

The non-residual numbers are

3, 6, 11, 12, 13, 15, 17, 21, 22, 23, 24, 26, 27, 29, 30.

Of these numbers the first, viz. 3, is a primitive root, since it satisfies neither of the two equations; and as the numbers less than 30, and prime to it, are 1, 7, 11, 13, 17, 19, 23, 29; all the primitive roots of 31 are as follows: viz. $3^1 = 3$, $3^7 = 17$, $3^{11} = 13$, $3^{13} = 24$, $3^{17} = 22$, $3^{19} = 12$, $3^{23} = 11$, $3^{29} = 21$. With respect to the other non-residual numbers, it will be found on trial that the first equation is satisfied by 6 and 26; the second by 15, 23, 27, 29; and both equations by 30.

We are now prepared to enter upon the solution of the problem for dividing the circle into as many equal parts as there are units in the prime number $p = 2n + 1$. If we conceive a polygon of p sides, to be inscribed in a circle, it will be admitted that the centre of gravity of the polygon coincides with the centre of the circle. Wherefore, if perpendiculars be drawn to any diameter of the circle from all the angles of the polygon, it follows, from the nature of the centre of gravity, that the sum of the cosines lying on one side of the centre of the circle will be equal to the sum of the cosines lying on the other side. Let $\varphi = \frac{360°}{p}$; and put u for the arc intercepted between the diameter and any angle of the polygon, then we shall have this equation, viz.

$$0 = \cos.u + \cos.(\varphi + u) + \cos.(2\varphi + u) \ldots . + \cos.(2n\varphi + u),$$

which is no more than the analytical expression of the geometrical property just mentioned. Now, suppose that the diameter passes through one of the angles of the polygon; then $u = 0$, and the equation becomes

$$0 = 1 + \cos.\varphi + \cos.2\varphi + \cos.3\varphi \ldots . + \cos.2n\varphi.$$

Let a be one of the primitive roots of the prime number p; then rejecting multiples of p, and paying no regard to the order, the terms of the geometrical progression,

$$a, a^2, a^3, a^4 \ldots\ldots a^{2n},$$

will be equal to the several numbers less than p. Wherefore, in the two series of arcs,

$$a\varphi, a^2\varphi, a^3\varphi, a^4\varphi \ldots\ldots a^{2n}\varphi,$$
$$\varphi, 2\varphi, 3\varphi, 4\varphi \ldots\ldots 2n\varphi,$$

every arc in the geometrical progression will either be equal to some one in the arithmetical progression, or will differ from it by a whole circumference, or circumferences. Hence the cosines of the first series of arcs may be substituted in the last equation for the cosines of the other series; and thus we have

$$-1 = \cos.a\varphi + \cos.a^2\varphi + \cos.a^3\varphi \ldots + \cos.a^{2n}\varphi.$$

Again, by Fermat's theorem, $a^{2n} - 1 = (a^n + 1)(a^n - 1)$ = a multiple of p; and because no primitive root of a prime number is the remainder of a square divided by that number, we have $a^n + 1$ = a multiple of p; and consequently $a^{n+\lambda} + a^\lambda$ = a multiple of p. It follows, therefore, that $a^{n+\lambda}\varphi + a^\lambda\varphi$ is equal to a multiple of the circumference of the circle; and hence,

$$\cos.a^{n+\lambda}\varphi = \cos.a^\lambda\varphi \qquad (A)$$

From this it appears that the cosines in the last equation may be distributed into two equal sums; one containing the cosines of all arcs from $a\varphi$ to $a^n\varphi$ inclusively, and the other the remaining cosines; consequently

$$-\frac{1}{2} = \cos.a\varphi + \cos.a^2\varphi + \cos.a^3\varphi \ldots \cos.a^n\varphi;$$

and because $\cos.a^n\varphi = \cos.\varphi$,

$$-\frac{1}{2} = \cos.\varphi + \cos.a\varphi + \cos.a^2\varphi \ldots\ldots + \cos.a^{n-1}\varphi. \quad (1)$$

Let $r = \frac{360°}{n}$; and put

$$e = \cos.r + \sin.r\sqrt{-1};$$

then all the powers of e with indices less than n will be different from one another, and all of them roots of the equation $e^n - 1 = 0$, the solution of which requires the division of the circle into only n, or $\frac{p - 1}{2}$, equal parts.

In what follows, we shall have continual occasion to consider the expression

$$\cos.a^\lambda\varphi + e^m\cos.a^{\lambda+1}\varphi + e^{2m}\cos.a^{\lambda+2}\varphi \ldots + e^{(n-1)m}\cos.a^{\lambda+n-1}\varphi;$$

and it will therefore be convenient to adopt an abridged mode of writing it. Now, the expression will be wholly known, and can be constructed when the two indices λ and m are given; and we may therefore denote it by the symbol $f(\lambda, m)$, placing always the index of a before the other. We shall invariably make the index of a positive, and suppose it reduced below n by means of the formula (A). In like manner we shall suppose that the index of e is always reduced below n by suppressing the multiples of n; and we shall write it sometimes positive and sometimes negative, observing that the negative indices may be always rendered positive by supplying the proper multiples of n; thus,

$$e^{-im} = e^{n-im} = e^{2n-im} = e^{3n-im}, \text{ \&c.}$$

According to the notation just explained, we have

$$f(o,m) = \cos.\varphi + e^{m} \cos. a\varphi + e^{2m} \cos. a^2\varphi .. + e^{(n-1)m} \cos. a^{n-1}\varphi,$$

$$f(o,-m) = \cos.\varphi + e^{-m} \cos. a\varphi + e^{-2m} \cos. a^2\varphi \ldots + e^{-(n-1)m} \cos. a^{n-1}\varphi.$$

And because $e^{\circ} = e^{n} = e^{-n} = 1$, the symbols $f(o, o)$, $f(o, n)$, $f(o, -n)$, will represent the series of cosines in the equation (1); so that we have

$$-\frac{1}{2} = f(o, o) = f(o, n) = f(o, -n).$$

The following formula is no more than a corollary from the preceding notation, viz.

$$e^{-\lambda m} \times f(o, m) = f(\lambda, m). \quad \text{(B)}$$

By means of the trigonometrical formula in common use, any powers and products of the cosines of the arc φ and its multiples may be reduced to a series of terms, containing the like cosines multiplied by given co-efficients. Wherefore, because $\cos. p\varphi = 1$, and likewise because the cosines of all arcs greater than $p\varphi$, $2p\varphi$, $3p\varphi$, &c. may be reduced to the cosines of arcs less than $p\varphi$, it follows that every rational and integral function of $\cos. \varphi$, $\cos. 2\varphi$, $\cos. 3\varphi$, &c. may be brought under this form of expression, viz.

$$\text{A} + \text{B} \cos.\varphi + \text{C} \cos. 2\varphi + \text{D} \cos. 3\varphi \ldots + \text{N} \cos. 2n\varphi.$$

Now, if we suppose the function we are considering to be such, that it retains the same value when any of the multiple arcs 2φ, 3φ, &c. is substituted for φ, the transformed expression will be possessed of the same property. But if we actually substitute the arcs 2φ, 3φ, &c. for φ in the foregoing expression, it will become successively

$$\text{A} + \text{B} \cos. 2\varphi + \text{C} \cos. 4\varphi + \text{D} \cos. 6\varphi +, \text{\&c.}$$
$$\text{A} + \text{B} \cos. 3\varphi + \text{C} \cos. 6\varphi + \text{D} \cos. 9\varphi +, \text{\&c.}$$
$$\text{\&c.}$$

each line containing the same cosines, although in a different order, because the series of arcs is the same when whole circumferences, or the multiples of $p\varphi$, are rejected; and all these expressions cannot have the same value unless $\text{B} = \text{C} = \text{D} = \text{\&c.}$; that is, unless the expression be of this form, viz.

$$\text{A} + \text{B} (\cos.\varphi + \cos. 2\varphi + \cos. 3\varphi \ldots + \cos. 2n\varphi),$$

which, in consequence of what was before proved, is equal to $\text{A} - \text{B}$. It is therefore demonstrated that every rational and integral function of $\cos. \varphi$, $\cos. 2\varphi$, $\cos. 3\varphi$, &c., which remains unchanged when any of the multiple arcs 2φ, 3φ, &c. is substituted for φ, has for its value an expression without cosines, and depending only upon the nature of the function.

If we introduce the arcs in geometrical instead of those n arithmetical progression, it is obvious that the substiution of the multiple arcs 2φ, 3φ, &c., for φ, is equivalent o the changing of φ into $a\varphi$, $a^2\varphi$, $a^3\varphi$, &c.; and hence any ational and integral function of the cosines of φ and its multiples, which remains invariable when φ is changed nto $a\varphi$, $a^2\varphi$, $a^3\varphi$, &c. is a quantity independent of the coines, or has its value expressed by a function from which he cosines are eliminated.

What has now been proved will enable us to appreciate he advantage arising from the introduction of the arcs in eometrical in place of those in arithmetical progression, in which principally consists the improvement that this theory owes to M. Gauss. The solution of the problem turns upon finding those functions of $\cos. \varphi$, $\cos. 2\varphi$, $\cos. 3\varphi$, &c. which have determinate values independent of the cosines; which functions, it has been proved, remain invariable when any of the multiple arcs 2φ, 3φ, &c. is substituted for φ. Now, although the substitution of any multiple arc, in place of the arc itself, always reproduces the same series of cosines, yet the order is irregular, and varies with every different multiple arc; and this circumstance makes it difficult to investigate what change the substitution will effect in a given function. On the other hand, by introducing the arcs in geometrical progression, the same order is still preserved, whatever substitution be made; and by this means every facility possible is obtained for investigating the functions sought.

The following properties are deducible from what has been proved. First, if m, m', m'', &c. be any numbers, none of which is equal to zero, or a multiple of n, and such that their sum is equal to n, or to a multiple of n, the product

$$f(o,m) \times f(o, m') \times f(o, m''), \text{ \&c.}$$

will be independent of the cosines of φ and its multiples, or will be an expression containing only the powers of e multiplied by numeral co-efficients.

For by the formula (B) we have

$$e^{-\lambda m} \times f(o, m) = f(\lambda, m)$$
$$e^{-\lambda m'} \times f(o, m') = f(\lambda, m')$$
$$e^{-\lambda m''} \times f(o, m'') = f(\lambda, m'')$$
$$\text{\&c.} \qquad \text{\&c.}$$

Therefore, by multiplying and observing that $e^{-\lambda m} \times e^{-\lambda m'} \times e^{-\lambda m''} \times, \text{\&c.} = 1$, because $\lambda \times (m + m' + m'' +, \text{\&c.})$ is a multiple of n, we get

$$f(o, m) \times f(o, m') \times f(o, m''), \text{\&c.} = f(\lambda, m) \times f(\lambda, m') \times f(\lambda, m''), \text{\&c.}$$

which shows that the product in question is not altered when φ is changed into $a^{\lambda}\varphi$. Consequently, according to what was before proved, the product is independent of the cosines.

It follows, as a corollary, that the product

$$f(o, m) \times f(o, -m)$$

is independent of the cosines.

Next, if m, m', m'', &c. be any numbers, and $s = m + m' + m''$, &c.; and if neither s nor any of the numbers m, m', m'', &c. be a multiple of n, we shall have

$$f(o, m) \times f(o, m') \times f(o, m''), \text{\&c.} = \text{M} \times f(o, s),$$

the quantity M being independent of the cosines, and containing only the powers of e multiplied by numeral co-efficients.

For, by the property already demonstrated, and its corollary, we have

$$f(o, m) \times f(o, m') \times f(o, m'') \times f(o, -s) = \text{A}$$
$$f(o, s) \times f(o, -s) = \text{A}';$$

A and A′ being quantities independent of the cosines. Therefore, by exterminating $f(o, -s)$, we get

$$f(o, m) \times f(o, m') \times f(o, m'') \times, \text{\&c.} = \frac{\text{A}}{\text{A}'} . f(o, s).$$

The foregoing properties are the foundations of the theory. But it is not enough to establish the principles by a general demonstration; it is also necessary to be able to compute the numerical values that occur in the application to particular problems. Therefore, supposing that m and m' are two numbers, and $s = m + m'$, none of the three numbers s, m, m', being a multiple of n, it is proposed to find the value of A in the equation

$$f(o, m) \times f(o, m') = \mathrm{A} \times f(o, s).$$

For this purpose, set down the several terms of $f(o, m')$ in their order; and below them write the terms of $f(o, m)$, placing first any term, as $e^{\lambda m} \cos.\, a^{\lambda}\varphi$, and the rest in their order, in this manner:

$$\cos.\,\varphi + e^{m'} \cos.\, a\,\varphi + e^{2m'} \cos.\, a^2\,\varphi \ldots\ldots + e^{(n-1)m'} \cos.\, a^{n-1}\,\varphi,$$

$$e^{\lambda m} \cos.\, a^{\lambda\varphi} + e^{(\lambda+1)m} \cos.\, a^{\lambda+1}\varphi + e^{(\lambda+2)m} \cos.\, a^{\lambda+2}\varphi \ldots + e^{(\lambda+n-1)m} \cos.\, a^{\lambda+n-1}\varphi.$$

Now, let every term in the lower line be multiplied into that which stands above it; and, separating the factor $e^{\lambda m}$, which is common to each product, let the symbol $e^{\lambda m} \times \Psi(\lambda)$ represent the sum of all the products; then

$$\Psi(\lambda) = \cos.\,\varphi \cos.\, a^{\lambda}\varphi + e^{s} \cos.\, a\,\varphi \cos.\, a^{\lambda+1}\varphi \ldots + e^{(n-1)s} \cos.\, a^{n-1}\varphi \cos.\, a^{\lambda+n-1}\varphi.$$

If we repeat this operation, so as to make every term of the lower line stand first in succession, it is evident that, by this means, every term of $f(o, m')$ will be multiplied by all the terms of $f(o, m)$; so that the sum of all the results will be the product sought. We therefore obtain

$$f(o, m) \times f(o, m') = \Psi(o) + e^{m}\Psi(1) + e^{2m}\Psi(2) \ldots + e^{(n-1)m}\Psi(n-1).$$

Let $a^{\lambda} + 1 = w$, and $a^{\lambda} - 1 = w'$; then, because the product of the cosines of the two arcs is equal to half the sum of the cosines of the sum and difference of the two arcs, we shall have

$$\Psi(\lambda) = \frac{1}{2}\left\{\cos.\, w\varphi + e^{s} \cos.\, a \,.\, w\varphi + e^{2s} \cos.\, a^2 \,.\, w\varphi +, \&c.\right\} + \frac{1}{2}\left\{\cos.\, w'\varphi + e^{s} \cos.\, a \,.\, w'\varphi + e^{2s} \cos.\, a^2 . w'\varphi +, \&c.\right\}.$$

In the first place, when $\lambda = 0$, $w = 2$, $w' = 0$; therefore

$$\Psi(o) = \frac{1}{2}\left\{\cos.\, 2\varphi + e^{s} \cos.\, a \,.\, 2\varphi + e^{2s} \cos.\, a^2 \,.\, 2\varphi \ldots e^{(n-1)s} \cos.\, a^{n-1} \,.\, 2\varphi\right\} + \frac{1}{2}\left\{1 + e^{s} + e^{2s} + e^{3s} \ldots + e^{(n-1)s}\right\}.$$

But $e^{n} - 1 = 0$; and hence $e^{ns} - 1 = 0$; or

$$0 = (1 - e^{s}) \,.\left\{1 + e^{s} + e^{2s} +, \&c. \ldots + e^{(n-1)s}\right\}:$$

and, according to the value assumed for e, the equation $1 - e^{s} = 0$ cannot take place when s is not a multiple of n; wherefore

$$0 = 1 + e^{s} + e^{2s} + e^{3s} \ldots + e^{(n-1)s}.$$

Now, if we put $a^{i} = 2$, we shall get

$$\Psi(o) = \frac{1}{2} f(i, s) = \frac{1}{2}\left\{\cos.\,.\, a^{i}\varphi + e^{s} \cos.\, a^{i+1}\varphi + e^{2s} \cos.\, a^{i+2}\varphi +, \&c.\right\}$$

Wherefore, on account of the formula (B), we finally get

$$\Psi(o) = \frac{1}{2} e^{-is} \times f(o, s).$$

Next, when λ is not equal to zero, let $h(\lambda)$ and $h'(\lambda)$ denote the numbers derived from λ by means of the equations

$$a^{\lambda} + 1 = a^{h(\lambda)},$$

$$a^{\lambda} - 1 = a^{h'(\lambda)};$$

then, by substituting $a^{h(\lambda)}$ and $a^{h'(\lambda)}$ for w and w', we shall get

$$\Psi(\lambda) = \frac{1}{2} f\Big(h(\lambda), s\Big) + \frac{1}{2} f\Big(h'(\lambda), s\Big):$$

and, on account of the formula (B),

$$\Psi(\lambda) = \left\{\frac{1}{2} e^{-(\lambda)s} + \frac{1}{2} e^{-h'(\lambda)s}\right\} . f(o, s).$$

Now, collecting all the parts in the expression of $f(o, m) \times f(o, m')$, we shall get these formulæ, viz.:

$$\left.\begin{aligned} f(o, m) \times f(o, m') &= \mathrm{A} \times f(o, s) \\ \mathrm{A} = \frac{1}{2} e^{-is} &+ \frac{1}{2} e^{m-h(1)s} + \frac{1}{2} e^{m-h'(1)s} \\ &+ \frac{1}{2} e^{2m-h(2)s} + \frac{1}{2} e^{2m-h'(2)s} \\ &+ \frac{1}{2} e^{3m-h(3)s} + \frac{1}{2} e^{3m-h'(3)s} \\ &\quad \&c. \qquad\qquad \&c \end{aligned}\right\} \quad (2)$$

As nothing changes in the expression of A except the indices m and s, it may be denoted by the abridged symbol (m, s), in which it is obvious that m' may be substituted for m; so that

$$\mathrm{A} = (m, s) = (m', s).$$

When s is equal to n, and $m' = n - m$, the product in question becomes $f(o, m) \times f(o, -m)$, which has been proved to be a quantity independent of the cosines. In this case, therefore, we shall have

$$f(o, m) \times f(o, -m) = \mathrm{B};$$

B being a quantity from which the cosines are eliminated, and which is now to be investigated.

If, in the foregoing case, we suppose $m' = n - m$ and $s = n$, we shall get

$$f(o, m) \times f(o, -m) = \Psi(o) + e^{m}\Psi(1) + e^{2m}\Psi(2) \ldots e^{(n-1)m}\Psi(n-1):$$

but here, because $e^{s} = e^{n} = 1$, e and its powers disappear from the expression of $\Psi(\mu)$, and we have

$$\Psi(\lambda) = \cos.\,\varphi \cos.\, a^{\lambda}\varphi + \cos.\, a\varphi \cos.\, a^{\lambda+1}\varphi + \cos.\, a^2\varphi \times \cos.\, a^{\lambda+2}\varphi +, \&c.;$$

and, by expanding the products of the cosines, as before,

$$\Psi(\lambda) = \frac{1}{2}\left\{\cos.\, w\varphi + \cos.\, a \,.\, w\varphi + \cos.\, a^2 w\varphi \ldots + \cos.\, a^{n-1} \,.\, w\varphi\right\} + \frac{1}{2}\left\{\cos.\, w'\varphi + \cos.\, a \,.\, w'\varphi + \cos.\, a^2 \,.\, w'\varphi \ldots + \cos.\, a^{n-1} \,.\, w'\varphi\right\}.$$

When $\lambda = 0$, $w = 2$, $w' = 0$; therefore

$$\Psi(o) = \frac{1}{2} . \left\{\cos.\, 2\varphi + \cos.\, a \,.\, 2\varphi + \cos.\, a^2 \,.\, 2\varphi \ldots + \cos.\, a^{n-1} \,.\, 2\varphi\right\}$$

$$+\frac{1}{2}\left\{1+1+1+1+1\,\ldots\ldots\ldots+1\right\}.$$

But no alteration is made in equation (1) when we substitute, instead of the arc φ, any one of its multiples, or, which is the same thing, change φ into $a\varphi$, $a^2\varphi$, &c.; because such substitution or change continually reproduces the same cosines. Thus it appears that the sum of the n cosines in $\Psi(o)$ is equal to $-\frac{1}{2}$; and we have

$$\Psi(o)=\frac{n}{2}-\frac{1}{4}.$$

For every other value of λ, w and w' are neither of them equal to zero, nor to a multiple of n; wherefore, according to what has just been said, the sum of the n cosines in each of the two parts of $\Psi(\lambda)$ is equal to $-\frac{1}{2}$; and thus, when λ is not equal to zero, we have

$$\Psi(\lambda)=\frac{1}{2}\times-\frac{1}{2}+\frac{1}{2}\times-\frac{1}{2}=-\frac{1}{2}.$$

By substituting the values of $\Psi(o)$ and $\Psi(\lambda)$, we get

$$f(o,m)\times f(o,-m)=$$
$$\frac{n}{2}-\frac{1}{4}-\frac{1}{2}\left(e^{m}+e^{2m}+e^{3m}\,\ldots+e^{(n-1)m}\right).$$

But, as was already proved,

$$-1=e^{m}+e^{2m}+e^{3m}\,\ldots.+e^{(n-1)m}:$$

wherefore

$$f(o,m)\times f(o,-m)=\frac{n}{2}-\frac{1}{4}+\frac{1}{2}=\frac{2n+1}{4}=\frac{1}{4}p.$$

Now, if we put $k^2=\frac{1}{4}p$, we have finally

$$f(o,m)\times f(o,-m)=k^2\,\ldots.(3).$$

When n is an even number, it is obvious that $f\left(o,\frac{n}{2}\right)=f\left(o,-\frac{n}{2}\right)$: therefore it follows as a corollary, that in this case

$$f\left(o,\frac{n}{2}\right)=f\left(o,-\frac{n}{2}\right)=\pm k=\pm\frac{1}{2}\sqrt{p}.$$

By applying the equation (2), first to the indices m and m', and then to the indices $n-m$ and $n-m'$, or to m and m' taken negatively, we deduce

$$f(o,m)\times f(o,m')=(m,s)\times f(o,s),$$
$$f(o,-m)\times f(o,-m')=(-m,-s)\times f(o,-s):$$

and by multiplying we shall get, on account of equation (3), this remarkable formula, viz.

$$(m,s)\times(-m,-s)=k^2\,\ldots(4).$$

By successive applications of the equation (2), we get

$$f(o,1)\times f(o,1)=(1,2)\times f(o,2),$$
$$f(o,1)\times f(o,2)=(1,3)\times f(o,3),$$
$$f(o,1)\times f(o,3)=(1,4)\times f(o,4),$$
&c.

By combining these equations, and writing P for f, $(o,1)$, we deduce

$$P^2=(1,2)\,.\,f(o,2),$$
$$P^3=(1,2)\,.\,(1,3)\,.\,f(o,3),$$
$$P^4=(1,2)\,.\,(1,3)\,.\,(1,4)\,.\,f(o,4),$$
&c.

Wherefore, when n is an even number,

$$P^{\frac{n}{2}}=(1,2).(1,3).(1,4)\,\ldots.\left(1,\frac{n}{2}\right).f\left(o,\frac{n}{2}\right);$$

and, by squaring and observing that, by equation (3), $\left\{f\left(o,\frac{n}{2}\right)\right\}^2=k^2$, we get

$$P^n=(1,2)^2.(1,3)^2.(1,4)^2\ldots\left(1,\frac{n}{2}\right)^2.k^2. \qquad (5).$$

When n is an odd number, we have, in like manner,

$$P^{\frac{n-1}{2}}=(1,2).(1,3).(1,4)\ldots\left(1,\frac{n-1}{2}\right)\times$$
$$f\left(o,\frac{n-1}{2}\right),$$
$$P^{\frac{n+1}{2}}=(1,2).(1,3).(1,4)\ldots\left(1,\frac{n+1}{2}\right)\times$$
$$f\left(o,\frac{n+1}{2}\right);$$

but, by equation (3), $f\left(o,\frac{n-1}{2}\right)\times f\left(o,\frac{n+1}{2}\right)=k^2$;

wherefore $P^n=(1,2)^2.(1,3)^2.(1,4)^2\ldots.\left(1,\frac{n-1}{2}\right)^2.$

$$\left(1,\frac{n+1}{2}\right).k^2\ldots(6).$$

Again, from the preceding expressions we get

$$f(o,2)=\frac{1}{(1,2)}.P^2;$$

and, by equation (4),

$$f(o,2)=\frac{(-1,-2)}{k^2}.P^2.$$

In like manner,

$$f(o,3)=\frac{(-1,-2)}{k^2}.\frac{(-1,-3)}{k^2}.P^3,$$
$$f(o,4)=\frac{(-1,-2)}{k^2}.\frac{(-1,-3)}{k^2}.\frac{(-1,-4)}{k^2}.P^4,$$
&c.

These formulæ need only be continued till we obtain the value of the function $f\left(o,\frac{n-2}{2}\right)$ when n is even, and of $f\left(o,\frac{n-1}{2}\right)$ when n is odd; the remaining functions $f(o,n-2)$, $f(o,n-3)$, &c. or, which is the same thing, $f(o,-2)$, $f(o-3)$, &c. being derived from the preceding values merely by changing the signs of the different indices of e. Thus, if we write P′ for $f(o,-1)$, we shall have

$$f(o,-2)=\frac{(1,2)}{k^2}.P'^2,$$
$$f(o,-3)=\frac{(1,2)}{k^2}.\frac{(1,3)}{k^2}.P'^3,$$
$$f(o,-4)=\frac{(1,2)}{k^2}.\frac{(1,3)}{k^2}.\frac{(1,4)}{k^2}.P'^4,$$
&c.

Now, ϱ being any number less than n, it has been shown that

$$o=1+e^{\varrho}+e^{2\varrho}+e^{3\varrho}\,\ldots.+e^{(n-1\varrho)}:$$

and hence if we attend to the nature of functions $f(o,o)$, $f(o,1)$, $f(o,2)$, &c. we shall readily get

$$\cos.\,a^{\varrho}\varphi=$$
$$\frac{f(o,o)}{n}+\frac{1}{n}.\left\{e^{-\varrho}.f(o,1)+e^{-2\varrho}f(o,2)+e^{-3\varrho}\right.$$
$$\left.f(o,3)+,\ \&c.\right\};$$

or, by arranging the terms differently, and because

$$f(o, o) = -\frac{1}{2},$$

$$\cos. a^{\varrho}\varphi = -\frac{1}{2n} + \frac{1}{n}.\left\{e^{-\varrho} f(o, 1) + e^{\varrho}.f(o, -1)\right\}$$
$$+\frac{1}{n}.\left\{e^{-2\varrho}.f(o, 2) + e^{2\varrho}.f(o, -2)\right\}$$
$$+\frac{1}{n}.\left\{e^{-3\varrho}.f(o, 3) + e^{3\varrho}.f(o, -3)\right\}$$
&c.

and it is to be observed that, when n is even, the last term is the single quantity $\frac{1}{n} \times e^{-\frac{n}{2}\varrho} \times f\left(o, \frac{n}{2}\right)$, which has no corresponding part. Now, this quantity is entirely known. For, since $e^n = 1$, we have $e^{\frac{n}{2}} = e^{-\frac{n}{2}} = \pm 1$; but e has been so assumed, that none of its powers with indices less than n are equal to unit; and, therefore, $e^{-\frac{n}{2}} = -1$, and $e^{-\frac{n}{2}\varrho} = (-1)^{\varrho}$. Again, by equation (3), $f\left(o, \frac{n}{2}\right) = \pm k$; wherefore we have

$$\frac{1}{n}.e^{-\frac{n}{2}\varrho}.f\left(o, \frac{n}{2}\right) = \frac{1}{n}.(-1)^{\varrho}. \times \pm k.$$

On the whole, the preceding analysis brings us to the following formulæ, which contain the solution of the problem, viz.

when n is even, by equation (5),

$$P^{\frac{n}{2}} = (1, 2).(1, 3).(1, 4)\ldots.\left(1, \frac{n}{2}\right) \times \pm k;$$

when n is odd, by equation (6),

$$P^n = (1, 2)^2.(1, 3)^2 (1, 4)^2 \ldots \left(1, \frac{n-1}{2}\right)^2.\left(1, \frac{n+1}{2}\right).k^2;$$

and by equation (2), $PP' = k^2$.

Finally, by substituting the values of $f(o, 2)$, $f(o, 3)$, &c. $f(o, -2)$, $f(o, -3)$, &c. in the expression of $\cos. a^{\varrho}\varphi$, we get

$$\cos. a^{\varrho}\varphi = -\frac{1}{2n} + \frac{k}{n}.\left\{\frac{e^{-\varrho}P}{k} + \frac{e^{\varrho}P'}{k}\right\}$$
$$+\frac{k}{n}.\left\{\frac{(-1, -2)}{k}.\left(\frac{e^{-\varrho}P}{k}\right)^2 + \frac{(1, 2)}{k}.\left(\frac{e^{\varrho}P'}{k}\right)^2\right\}$$
$$+\frac{k}{n}.\left\{\frac{(-1, -2)}{k}.\frac{(-1, -3)}{k}.\left(\frac{e^{-\varrho}P}{k}\right)^3\right.$$
$$\left.+\frac{(1, 2)}{k}.\frac{(1, 3)}{k}\left(\frac{e^{\varrho}P'}{k}\right)^3\right\}$$
$+$, &c.

the series of terms must be continued till the last index of $\frac{e^{-\varrho}P}{k}$ and $\frac{e^{\varrho}P'}{k}$ is $\frac{n-1}{2}$ when n is odd, and $\frac{n-2}{2}$ when n is even; and, in this last case, the quantity $\frac{1}{n} \times (-1)^{\varrho} \times \pm k$, must be added, prefixing to k the same sign that is given to it in the value of $P^{\frac{n}{2}}$.

The solution of the problem is thus reduced to the computation of the functions (1, 2), (1, 3), &c. which requires no more than the substitution of 1 for m, and of 2, 3, 4, &c. successively for s, in the expression of A, equation (2). The half of these functions that have negative indices are deduced from the other half, merely by changing the signs of the several indices of e, or by means of equation (4). All the cosines sought are found by substituting o, 1, 2, 3, &c. successively for ϱ. Although the function P is susceptible of n different values, represented by x, ex, e^2x, &c.; yet the same cosines are deduced from any one of these values. By this means all ambiguity is avoided with regard to the system of values that represent the cosines; but the numerical value that must be attached to each particular cosine remains quite indeterminate, because φ may equally stand for $\frac{360°}{p}$, $2 \times \frac{360°}{p}$, $3 \times \frac{360°}{p}$, &c. The adaptation of the numerical quantities to the geometrical cosines must be made out by means of their relative magnitudes; the largest number answering to the greatest cosine. But when the value of one cosine is fixed, the rest are unambiguously determined by means of their indices.

In the formula for $\cos. a^{\varrho}\varphi$ all the terms in which two quantities are combined have real values, although their forms are imaginary. But it is not difficult to transform them into equivalent quantities without the imaginary sign.

It is manifest that the functions (1, 2) and (— 1, — 2) are of this form, viz.

$$(1, 2) = A + Be + Ce^2 + De^3 \ldots + Ne^{n-1},$$
$$(-1, -2) = A + Be^{-1} + Ce^{-2} + De^{-3} \ldots + Ne^{-(n-1)},$$

A, B, C, &c. denoting given co-efficients.

But we have generally

$$e^{\lambda} = \cos. \lambda\tau + \sin. \lambda\tau\sqrt{-1},$$
$$e^{-\lambda} = \cos. \lambda\tau - \sin. \lambda\tau\sqrt{-1}:$$

wherefore, by combining the two expressions of (1, 2) and (— 1, — 2), we shall readily get

$$\frac{(1, 2) + (-1, -2)}{2} = A + B\cos. \tau + C\cos. 2\tau +, \&c.$$
$$\frac{(1, 2) - (-1, -2)}{2} = \qquad B\sin. \tau + C\sin. 2\tau +, \&c.$$

But, on account of equation (4), we may assume

$$(1, 2) = k(\cos. \beta + \sin. \beta\sqrt{-1}),$$
$$(-1, -2) = k(\cos. \beta - \sin. \beta\sqrt{-1});$$

and, by substituting these values in the last expressions, we get

$$k\cos. \beta = A + B\cos. \tau + C\cos. 2\tau +, \&c.$$
$$k\sin. \beta = \qquad B\sin. \tau + C\sin. 2\tau +, \&c.$$

by which means the arc β is determined without ambiguity, since both its sine and cosine are ascertained. In like manner are determined the several arcs in the formulæ

$$(1, 3) = k(\cos. \beta' + \sin. \beta'\sqrt{-1}),$$
$$(-1, -3) = k(\cos. \beta' - \sin. \beta'\sqrt{-1}),$$
$$(1, 4) = k(\cos. \beta'' + \sin. \beta''\sqrt{-1}),$$
$$(-1, -4) = k(\cos. \beta'' - \sin. \beta''\sqrt{-1}),$$
&c.

Again, because $PP' = k^2$, we may assume

$$P = k(\cos. w + \sin. w\sqrt{-1}),$$
$$P' - k(\cos. w - \sin. w\sqrt{-1}),$$

And if these values, and the similar values of the functions (1, 2), (1, 3), &c. be substituted in the value of $P^{\frac{n}{2}}$, we shall readily deduce, when n is an even number,

$$\frac{n}{2} \cdot w = \beta + \beta' + \beta'' +, \&c.$$

When n is an odd number, we must separate the function $\left(1, \frac{n+1}{2}\right)$ from the rest, by supposing $\left(1, \frac{n+1}{2}\right) = k$ $(\cos.\gamma + \sin.\gamma\sqrt{-1})$: and then, by means of equation (6), we shall easily obtain

$$nw = 2(\beta + \beta' + \beta'' +, \&c.) + \gamma.$$

The two last formulæ determine the arc w; and we likewise have

$$\frac{e^{-\varrho}P}{k} = \cos.(w - \varrho\tau) + \sin.(w - \varrho\tau)\sqrt{-1},$$

$$\frac{e^{\varrho}P'}{k} = \cos.(w - \varrho\tau) - \sin.(w - \varrho\tau)\sqrt{-1};$$

and, by putting $w^{(\varrho)} = w - \varrho\tau$,

$$\frac{e^{-\varrho}P}{k} = \cos. w^{(\varrho)} + \sin. w^{(\varrho)}\sqrt{-1},$$

$$\frac{e^{\varrho}P}{k} = \cos. w^{(\varrho)} - \sin. w^{(\varrho)}\sqrt{-1}.$$

Finally, by substituting the different values exhibited above in the formula for $\cos. a^{\varrho}\varphi$, we shall get

$$\begin{aligned}\cos. a^{\varrho}\varphi = -\frac{1}{2n} &+ \frac{2k}{n}.\cos. w^{(\varrho)} \\ &+ \frac{2k}{n}.\cos.(2w^{\varrho} - \beta) \\ &+ \frac{2k}{n}.\cos.(3w^{(\varrho)} - \beta - \beta') \\ &+ \frac{2k}{n}.\cos.(4w^{(\varrho)} - \beta - \beta' - \beta'') \\ &\&c.\end{aligned}$$

the series of terms being continued till all the arcs β, β', β'', &c. are taken in when n is odd; and till they are all taken in except the last when n is even, in which case also the quantity $(-1)^{\varrho}.\frac{k}{n}$ must be added.

By the preceding analysis the division of the circle into p equal parts is accomplished, when p is a prime number, by dividing a given arc into n or $\frac{p-1}{2}$ equal parts. And this conclusion agrees with the general proposition of M. Gauss. For the nth part of a given arc is found by bisecting as often as n is divisible by 2, trisecting as often as it is divisible by 3, and so on. When n is a power of two, as in the case of the polygon of 17 sides, the solution is effected by repeated bisections, and thus comes under the elementary geometry. Supposing the division of the circle to be accomplished, we must further resolve the quadratic equation

$$x + \frac{1}{x} = 2\cos..\frac{\lambda \times 360°}{p},$$

in order to find the roots of the binomial equation $x^p - 1 = 0$.

The following examples are subjoined for the sake of illustrating the method of calculation. And, in the first place, we may take the case of $p = 11$ equivalent to finding the roots of the equation $x^{11} - 1 = 0$, which was first solved by Vandermonde, and has been considered both by Lagrange and Legendre. Here, $n = 5$; $k = \frac{1}{2}\sqrt{11}$; $\tau = \frac{360°}{5} = 72°$; $e = \cos.\tau + \sin.\tau\sqrt{-1}$; and, as 2 is a primitive root of 11, we may suppose $a = 2$. In order to find the numbers $h(\lambda)$ and $h'(\lambda)$, write down the series 1, 2, 3, &c. as far as n or 5; and, above each number, write the power of a equal to it when the multiples of 11 are rejected, taking always the least remainder, whether positive or negative: thus,

$$\begin{matrix} a^0 & a^1 & a^3 & a^2 & a^4 \\ 1 & 2 & 3 & 4 & 5. \end{matrix}$$

In this arrangement of the powers of a, it is evident that, λ denoting any index, $h(\lambda)$ is the next on the right hand, and $h'(\lambda)$ the next on the left hand: we have, therefore,

$$i = 1,$$

$$\begin{aligned} h(1) &= 3, & h'(1) &= 0, \\ h(2) &= 4, & h'(2) &= 3, \\ h(3) &= 2, & h'(3) &= 1, \\ h(4) &= 4, & h'(4) &= 2. \end{aligned}$$

Now, substitute these numbers in the expression of A, equation (2), and likewise put $m = 1$; then

$$\begin{aligned} A = \frac{1}{2}e^{-s} &+ \frac{1}{2}e^{1-3s} + \frac{1}{2}e \\ &+ \frac{1}{2}e^{2-4s} + \frac{1}{2}e^{2-3s} \\ &+ \frac{1}{2}e^{3-2s} + \frac{1}{2}e^{3-s} \\ &+ \frac{1}{2}e^{4-4s} + \frac{1}{2}e^{4-2s}. \end{aligned}$$

In order to find (1, 2) and (1, 3), we have only to substitute 2 and 3 for s in the expression of A; hence

$$(1, 2) = 1 + 2e + \frac{1}{2}e^3 + e^4,$$

$$(1, 3) = 1 + \frac{1}{2}e + 2e^2 + e^3;$$

which values will, in this case, be rendered somewhat more simple by combining them with the equation $0 = 1 + e + e^2 + e^3 + e^4$: and thus we get

$$(1, 2) = e - e^2 - \frac{1}{2}e^3 = m,$$

$$(1, 3) = e^2 - e^4 - \frac{1}{2}e = \mu.$$

The functions $(-1, -2)$ and $(-1, -3)$ are found by subtracting the indices of e in the values of (1, 2) and (1, 3) from 5, which is equivalent to changing the signs of the indices; therefore

$$(-1, -2) = e^4 - e^3 - \frac{1}{2}e^2 = m,$$

$$(-1, -3) = e^3 - e - \frac{1}{2}e^4 = \mu'.$$

And it will be found, by actually multiplying, that

$$mm' = k^2 = \frac{11}{4} \text{ and } \mu\mu' = k^2 = \frac{11}{4}.$$

These values being found, we have, according to the foregoing method,

$$P^5 = (1, 2)^2 \cdot (1, 3) \cdot k^2 = m^2\,\mu \cdot k^2,$$

$$P'^5 = \frac{k^{10}}{P^5} = (-1, -2)^2 . (-1, -3) . k^2 = m'^2\,\mu' . k^2;$$

and hence $\frac{P}{k} = \frac{1}{k}(m^2\mu . k^2)^{\frac{1}{5}}$,

$$\frac{P'}{k} = \frac{1}{k}(m'^2\mu' . k^2)^{\frac{1}{5}},$$

$$\frac{m'}{k} \cdot \frac{P^2}{k^2} = \frac{1}{k}(m'\mu^2 . k^2)^{\frac{1}{5}},$$

$$\frac{m}{k} \cdot \frac{P'^2}{k^2} = \frac{1}{k}(m\mu'^2 . k^2)^{\frac{1}{5}};$$

wherefore we have

$$\cos.\, a^{\varrho}\varphi = -\frac{1}{10} + \frac{e^{-\varrho}}{5} \,.\, (m^2\mu \,.\, k^2)^{\frac{1}{5}} + \frac{e^{\varrho}}{5} \,.\, (m'^2\mu' \,.\, k^2)^{\frac{1}{5}}$$

$$+\frac{e^{-2\varrho}}{5} \,.\, (m'\mu^2 \,.\, k^2)^{\frac{1}{5}} + \frac{e^{2\varrho}}{5} \,.\, (m\mu'^2 \,.\, k^2)^{\frac{1}{5}}\,.$$

If, in this expression, we make $\varrho=0$, and substitute the numerical values of k^2, and of e and its powers, in the quantities under the radical sign, the result will coincide with the formula of Vandermonde, and with the calculation of Lagrange.

The expression just found being imaginary, if it be required to reduce it to a form fit for calculation, we must begin with substituting the values of e and its powers in m and μ: then

$$m=(\cos.\, \tau - \cos.\, 2\tau - \frac{1}{2}\cos.\, 3\tau)$$

$$+(\sin.\, \tau - \sin.\, 2\tau - \frac{1}{2}\sin.\, 3\tau) \,.\, \sqrt{-1},$$

$$\mu=(\cos.\, 2\tau - \cos.\, 4\tau - \frac{1}{2}\cos.\, \tau)$$

$$+ (\sin.\, 2\tau - \sin.\, 4\tau - \frac{1}{2}\sin.\, \tau) \,.\, \sqrt{-1}.$$

Now, $\cos.\, \tau = \cos.\, 4\tau = -\frac{1}{4}+\frac{1}{4}\sqrt{5}$, and $\cos.\, 2\tau = \cos.\, 3\tau = -\frac{1}{4}-\frac{1}{4}\sqrt{5}$; also $\sin.\, \tau = -\sin.\, 4\tau$, and $\sin.\, 2\tau = -\sin.\, 3\tau$: wherefore

$$m=(\cos.\, \tau - \frac{3}{2}\cos.\, 2\tau) + (\sin.\, \tau - \frac{1}{2}\sin.\, 2\tau) \,.\, \sqrt{-1},$$

$$\mu=(\cos.\, 2\tau - \frac{3}{2}\cos.\, \tau) + (\sin.\, 2\tau + \frac{1}{2}\sin.\, \tau) \,.\, \sqrt{-1}.$$

Again,

$$m=k\,(\cos.\, \beta + \sin.\, \beta \,.\, \sqrt{-1}),$$
$$\mu=k\,(\cos.\, \gamma + \sin.\, \gamma\, \sqrt{-1});$$

consequently

$$\cos.\, \beta = \frac{1}{k}(\cos.\, \tau - \frac{3}{2}\cos.\, 2\tau) = \frac{1+5\sqrt{5}}{4\sqrt{11}},$$

$$\sin.\, \beta = \frac{1}{k}(\sin.\, \tau - \frac{1}{2}\sin.\, 2\tau),$$

$$\cos.\, \gamma = \frac{1}{k}(\cos.\, 2\tau - \frac{3}{2}\cos.\, \tau) = \frac{-1+5\sqrt{5}}{4\sqrt{11}},$$

$$\sin.\, \gamma = \frac{1}{k}(\sin.\, 2\tau + \frac{1}{2}\sin.\, \tau).$$

Hence

$$\beta = 23^\circ\ 20'\ 46'',$$
$$\gamma = 140\ \ 7\ \ 6\tfrac{1}{2},$$
$$5\omega = 2\beta+\gamma = 186\ \ 48\ \ 38\tfrac{1}{2},$$
$$\omega = 37\ \ 21\ \ 44,$$

$$\omega^{(\varrho)} = \omega - \varrho \times 72^\circ:$$

$$\cos.\, a_{\varrho}\varphi = -\frac{1}{10} + \frac{\sqrt{11}}{5} \,.\, \left\{\cos.\, \omega^{(\varrho)} + \cos.\, (2\omega^{\varrho} - \beta)\right\}.$$

By making ϱ successively equal to 0, 1, 2, 3, 4, the formula will give all the ten cosines of a polygon of eleven sides inscribed in a circle; because $\cos.\, \frac{360^\circ}{11} = \cos.\, 10 \,.\, \frac{360^\circ}{11}$, $\cos.\, 2 \,.\, \frac{360^\circ}{11} = \cos.\, 9 \,.\, \frac{360^\circ}{11}$, &c. It determines also the order of the arcs to which the numerical quantities belong; so that when the value of one cosine is fixed, the values of all the rest are likewise ascertained.

This last formula coincides with the calculation of Legendre.

The next example shall be the case of $p=17$. Then, $n=8$, $k=\frac{1}{2}\sqrt{17}$, $\tau=\frac{360^\circ}{8}=45^\circ$, and $e=\cos.\, \tau + \sin.\, \tau\sqrt{-1}$; and, 3 being one of the primitive roots of 17, we may take $a=3$. Now, arranging the powers of a as in the last example, we have

$$a^0,\ a^6,\ a^1\ a^4,\ a^5,\ a^7,\ a^3,\ a^2$$
$$1,\ 2,\ 3,\ 4,\ 5,\ 6,\ 7,\ 8:$$

and hence,

$$i=6$$

$h(1)=4$, $h'(1)=6$,
$h(2)=2$, $h'(2)=3$,
$h(3)=2$, $h'(3)=7$,
$h(4)=5$, $h'(4)=1$,
$h(5)=7$, $h'(5)=4$,
$h(6)=1$, $h'(6)=0$,
$h(7)=3$, $h'(7)=5$.

By substituting these numbers in the expression of A, and likewise by putting $m=1$, we get

$$\mathrm{A}=\frac{1}{2}e^{-6s}+\frac{1}{2}e^{1-4s}+\frac{1}{2}e^{1-6s}$$
$$+\frac{1}{2}e^{2-2s}+\frac{1}{2}e^{2-3s}$$
$$+\frac{1}{2}e^{3-2s}+\frac{1}{2}e^{3-7s}$$
$$+\frac{1}{2}e^{4-5s}+\frac{1}{2}e^{4-s}$$
$$+\frac{1}{2}e^{5-7s}+\frac{1}{2}e^{5-4s}$$
$$+\frac{1}{2}e^{6-s}+\frac{1}{2}e^{6}$$
$$+\frac{1}{2}e^{7-3s}+\frac{1}{2}e^{7-5s}.$$

In order to have the functions (1, 2), (1, 3), (1, 4), nothing more is necessary than to substitute 2, 3, 4 for s in the expression of A: then, observing that $e+e^5=0$, $e^2+e^6=0$, $e^3+e^7=0$, we readily get

$$(1,\ 2) = \frac{3}{2}e^4+e^7+e^5 = -\frac{3}{2}-\sqrt{-2} = -m,$$

$$(1,\ 3) = 1+\frac{1}{2}e^4+2e^6 = \frac{1}{2}-2\sqrt{-1} = n,$$

$$(1,\ 4) = \frac{3}{2}+e+e^3 = \frac{3}{2}+\sqrt{-2} = m:$$

and hence

$$(-1,\ -2) = \frac{3}{2}e^4+e+e^3 = -\frac{3}{2}+\sqrt{-2} = -m',$$

$$(-1,\ -3) = 1+\frac{1}{2}e^4+2e^2 = \frac{1}{2}+2\sqrt{-1} = n',$$

$$(-1,\ -4) = \frac{3}{2}+e^7+e^5 = \frac{3}{2}-\sqrt{-2} = m'.$$

These values being found, we next have

$$\mathrm{P}^4 = (1,\ 2) \,.\, (1,\ 3) \,.\, (1,\ 4) \,.\, f(0,\ 4);$$
$$f(0,\ 4) = \pm k;$$

therefore, making $f(0,\ 4) = -k$,

$$\mathrm{P}^4 = m^2nk,$$

$$\mathrm{P}'^4 = \frac{k^8}{\mathrm{P}^4} = m'^2n'k;$$

and hence

$$\frac{1}{k}\mathrm{P} = \frac{1}{k}(m^2nk)^{\frac{1}{4}};\ \frac{1}{k}\,.\,\mathrm{P}' = \frac{1}{k}(m'^2n'k)^{\frac{1}{4}};$$

$$-\frac{m'}{k}\cdot\frac{\mathrm{P}^2}{k^2}=-\frac{1}{k}\cdot\sqrt{nk}\,;\ -\frac{m}{k}\cdot\frac{\mathrm{P}^2}{k^2}=-\frac{1}{k}\sqrt{n'k}\,;$$

$$-\frac{m'}{k}\cdot\frac{n'\mathrm{P}^3}{kk^3}\cdot=-\frac{1}{k}(m^2n'k)^{\frac{1}{4}}\,;\ -\frac{m}{k}\cdot\frac{n}{k}\cdot\frac{\mathrm{P}'^3}{k^3}$$

$$=-\frac{1}{k}(m'^2nk)^{\frac{1}{4}}\,;$$

$$\cos.\,a^{\varrho}\varphi=-\frac{1}{16}-(-1)^{\varrho}\cdot\frac{\sqrt{17}}{16}$$

$$+\frac{1}{8}\cdot\left\{e^{-\varrho}(m^2nk)^{\frac{1}{4}}+e^{\varrho}\,(m'^2n'k)^{\frac{1}{4}}\right\}$$

$$-\frac{1}{8}\cdot\left\{e^{-2\varrho}(nk)^{\frac{1}{2}}+e^{2\varrho}\,(n'k)^{\frac{1}{2}}\right\}$$

$$-\frac{1}{8}\left\{e^{-3\varrho}\,(m^2n'k)^{\frac{1}{4}}+e^{3\varrho}\,(m'^2nk)^{\frac{1}{4}}\right\}.$$

In order to reduce this expression, we shall put

$$\varphi(\varrho)=e^{-2\varrho}\sqrt{nk}+e^{2\varrho}\sqrt{n'k},$$

$$\Psi(\varrho)=e^{-\varrho}(m^2nk)^{\frac{1}{4}}+e^{\varrho}(m'^2n'k)^{\frac{1}{4}}$$

$$-e^{-3\varrho}\,(m^2n'k)^{\frac{1}{4}}-e^{3\varrho}(m'^2nk)^{\frac{1}{4}}.$$

And because $e^4=e^{-4}=-1$, we get $e^{6\varrho}=e^{-2\varrho}=(-1)^{\varrho}\,.\,e^{2\varrho}$, and $e^{-6\varrho}=e^{2\varrho}=(-1)^{\varrho}\,.\,e^{-2\varrho}$. Wherefore, by squaring,

$$\left\{\varphi(\varrho)\right\}^2=2k^2+(-1)^{\varrho}\,.\,k,$$

$$\left\{\Psi(\varrho)\right\}^2=4k^2-6k(-1)^{\varrho}+3\varphi(\varrho)-2k\,.\,\varphi(\varrho)\,.\,(-1)^{\varrho}.$$

Now, in the formula for cos. $a^{\varrho}\varphi$, viz. $\cos.\,a^{\varrho}\varphi=-\frac{1}{16}-(-1)^{\varrho}.\frac{\sqrt{17}}{16}-\frac{1}{8}\,\varphi(\varrho)-\frac{1}{8}\Psi(\varrho)$, if we change ϱ into $\varrho+4$, no alteration will be produced, except that $\Psi(\varrho)$ will change its sign; for it is obvious that

$$\Psi(\varrho+4)=e^4\,.\,\Psi(\varrho)=-\Psi(\varrho).$$

Hence we readily deduce these two equations, viz.

$$\frac{1}{2}(\cos.\,a^{\varrho}\varphi+\cos.\,a^{\varrho+4}\varphi)=-\frac{1}{16}-(-1)^{\varrho}\,.\,\frac{\sqrt{17}}{16}-\frac{1}{8}\varphi(\varrho),$$

$$\frac{1}{4}(\cos.\,a^{\varrho}\varphi-\cos.\,a^{\varrho+4}\varphi)^2=\frac{1}{64}\times\left\{\Psi(\varrho)\right\}^2.$$

If we suppose $\varrho=0$, then

$$\left\{\varphi(0)\right\}^2=2k^2+k\,;$$

wherefore

$$\frac{1}{2}(\cos.\,\varphi+\cos.\,a^4\varphi)=-\frac{1}{16}-\frac{\sqrt{17}}{16}-\frac{1}{8}\sqrt{2k^2+k},$$

$$\frac{1}{4}(\cos.\,\varphi-\cos.\,a^4\varphi)^2=\frac{1}{64}\cdot\left\{4k^2-6k-(2k-3)\times\sqrt{2k^2+k}\right\}.$$

And, when $\varrho=2$, then

$$\varphi(2)=e^4\,.\,\varphi(0)=-\varphi(0)\,;$$

wherefore

$$\frac{1}{2}(\cos.\,a^2\varphi+\cos.\,a^6\varphi)=-\frac{1}{16}-\frac{\sqrt{17}}{16}+\frac{1}{8}\sqrt{2k^2+k},$$

$$\frac{1}{4}(\cos.\,a^2-\cos.\,a^6\varphi)^2=\frac{1}{64}\cdot\left\{4k^2-6k+(2k-3)\times\sqrt{2k^2+k}\right\}.$$

Next, suppose $\varrho=1$, then

$$\left\{\varphi(1)\right\}^2=2k^2-k\,;$$

wherefore

$$\frac{1}{2}(\cos.\,a\varphi+\cos.\,a^5\varphi)=-\frac{1}{16}+\frac{\sqrt{17}}{16}+\frac{1}{8}\sqrt{2k^2-k},$$

$$\frac{1}{4}(\cos.\,a\varphi-\cos.\,a^5\varphi)^2=\frac{1}{64}\cdot\left\{4k^2+6k+(2k+3)\sqrt{2k^2-k}\right\}:$$

and, finally, making $\varrho=3$, we get

$$\varphi(3)=e^4\times\varphi(1)=-\varphi(1)\,;$$

wherefore

$$\frac{1}{2}(\cos.\,a^3\varphi+\cos.\,a^7\varphi)=-\frac{1}{16}+\frac{\sqrt{17}}{16}-\frac{1}{8}\sqrt{2k^2-k},$$

$$\frac{1}{4}(\cos.\,a^3\varphi-\cos.\,a^7\varphi)^2+\frac{1}{64}\cdot\left\{4k^2+6k-(2k+3)\sqrt{2k^2-k}\right\}.$$

These formulæ enable us to find the numerical values of all the cosines sought; observing always that φ is indeterminate, and varies with the primitive root from which the solution is deduced. (K. K.)

EQUATOR, or ÆQUATOR, in *Astronomy* and *Geography*, a great circle of the sphere, equally distant from the two poles of the world, or having the same poles with those of the world. It is called the *equator*, because when the sun is in it the days and nights are *equal;* whence also it is denominated the *equinoctial*, and, when drawn on maps and planispheres, the *equinoctial line*, or simply the *line*. Every point of the equator is distant a quadrant from the poles of the world; and hence it follows that the equator divides the sphere into two hemispheres, in one of which is the northern, and in the other the southern pole.

EQUERY, or ECURY, a grand stable or lodge for horses, furnished with all suitable conveniences, as stalls, manger, rack, &c. The word is formed from the French *écurie*, which signifies the same thing. Some, again, derive *écurie* from the Latin *scuria*, which not only denotes a place for beasts to be stalled in, but also a grange or barn. But a more probable derivation is from *equile*, a stable for horses, from *equus*, horse. Some think that the word *stable* properly relates only to bullocks, cows, sheep, hogs, &c. and *equery* to horses, mules, &c.

A *simple equery* is that provided for one row of horses; a *double equery* that provided for two, with a passage in the middle; or two passages, the horses being placed head to head.

Under the term equery are sometimes also comprehended the lodgings and apartments of the equeries, grooms, pages, and others.

EQUERY (*écuyer*) is also an officer who has the care and management of the horses of a king or prince.

EQUES AURATUS is used to signify a knight-bachelor, called *auratus*, because anciently none but knights might gild or beautify their armour or other habiliments of war with gold. In law this term is not used, but instead of it *miles*, and sometimes *chevalier*.

EQUESTRIA, among the Romans, a place in the theatre occupied by the equites or knights.

EQUESTRIAN (*equestris*), a term chiefly used in the phrase *equestrian statue*, which signifies a statue representing a person mounted on horseback. The word is formed from the Latin *eques*, knight or horseman, from *equus*, horse.

Equestrian Games, among the Romans, horse-races, of which there were five kinds; the *prodromus* or *plain horse-race*, the *chariot-race*, the *decursory-race* about funeral piles, the *ludi sevirales*, and the *ludi neptunales*.

EQUIANGULAR, in *Geometry*, an epithet applied to figures the angles of which are all equal; such are a square, an equilateral triangle, and the like.

EQUIDISTANT, an appellation given to things placed at equal distances from some fixed point or place to which they are referred.

EQUILATERAL, in general, something that has equal sides; as an equilateral triangle.

EQUILIBRIUM, in *Mechanics*, is when the two ends of a lever or balance hang so exactly even and level that neither ascends or descends, but both remain in a position parallel to the horizon; which is occasioned by their being both charged with an equal weight.

EQUIMULTIPLES, in *Arithmetic* and *Geometry*, are numbers or quantities multiplied by one and the same number or quantity. Hence equimultiples are always in the same ratio to each other as the simple quantities before multiplication; thus, if 6 and 8 are multiplied by 4, the equimultiples 24 and 32 will be to each other as 6 to 8.

EQUINOCTIAL, or ÆQUINOCTIAL, in *Astronomy*, a great and immoveable circle of the sphere, under which the equator moves in its diurnal motion.

The equinoctial, or æquinoctial line, is ordinarily confounded with the equator; but there is a difference, the equator being moveable and the equinoctial immoveable; the equator being drawn about the convex surface of the sphere, and the equinoctial on the concave surface of the *magnus orbis*.

Whenever the sun, in his progress through the ecliptic, comes to this circle, the days and nights are equal all over the globe; for then he rises due east and sets due west, which he never does at any other time of the year; and hence the denomination, from *æquus*, equal, and *nox*, night, *quia æquat diem nocti*.

The equinoctial, then, is the circle which the sun describes, or appears to describe, at the time of the equinoxes; that is, when the length of the day is everywhere equal to that of the night, which happens twice a year.

Equinoctial Points are the two points in which the equator and ecliptic intersect each other; the one, being in the first point of Aries, is called the *vernal point* or *equinox;* and the other, in the first point of Libra, is denominated the *autumnal point* or *equinox*.

Equinoctial Dial, a dial, the plane of which is parallel to that of the equinoctial. See DIAL.

EQUINOX, or ÆQUINOX, in *Astronomy*, the time when the sun enters one of the equinoctial points.

The equinoxes happen when the sun is in the equinoctial circle, and the days are equal to the nights throughout the world, which is the case twice a year; namely, about the 20th of March and the 23d of September, the former being the vernal and the latter the autumnal equinox.

EQUIPOLLENCE, in *Logic*, is when there is an equivalence between any two or more terms or propositions; that is, when they amount to the same thing, though they express it differently. Such terms or propositions are said to be *equipollent*.

EQUIRIA, in *Antiquity*, a festival instituted by Romulus, and celebrated on the 27th of February, in honour of Mars. There were horse-races at this festival.

EQUITES, an order of men in the commonwealth of Rome, to which we can furnish no exact parallel in modern times. They seem, indeed, to have resembled in some degree the gentry of England; with this difference, however, that they enjoyed peculiar privileges, and were more of a separate caste than any body of men which can now be pointed out. Their origin goes back to the earliest times of Roman history, though we can perceive, even from the legendary statements of Livy and Dionysius, that their constitution and mode of selection had been changed in the course of ages. During the reign of the kings they evidently appear to have been of noble birth, the younger branches of patrician families. This we may infer from the statement of Polybius (vi. 20), when he says that the knights *now* are chosen according to fortune, evidently intimating that their selection had depended on a different principle at a previous period. Romulus is said to have divided them into three centuries; and the very names of Ramnenses, Titienses, and Luceres, by which he designated them, point out distinctly their high origin. Both Tullus Hostilius and Tarquinius added to their number; but it was Servius Tullius (576 B. C.) who first organised them into a distinct body, and compelled the state to contribute annually to their maintenance. It is difficult to perceive in what way we are to explain the statement of Livy (i. 43), that the sum of ten thousand pounds of brass was given to each for the purchase of a horse; an enormous sum, when compared with that at which oxen and sheep were rated in the table of penalties. They were bound of course to be provided with a noble steed, and may have been obliged to replace it if it fell from any casualty in war. The accoutrements, too, and a slave to take charge of it, were possibly all included in this large sum. But whether, when the censor ordered the knight to sell his horse, it was the intention that the outfit money should be refunded to the state, we have now no means of determining. Livy tells us also that a tax was imposed on each *vidua*, of two thousand pounds of brass, to maintain a knight's horse. This certainly sounds very strange; for it seems inconceivable that there should have been such a large number of rich widows; and even though we understand by the word *vidua* every single woman, maiden as well as widow, we do not think that we thereby get out of the difficulty.

As early as 400 B. C. we find that a certain fortune was required to enable a man to be raised to the rank of eques. In that year, at the siege of Veii, we are told that those who possessed the requisite fortune, but to whom horses had not been assigned, offered to provide these at their own expense. This proposal was accepted; and then it was, according to Livy (v. 7), that they first received regular pay. In 303 B. C. the censors Q. Fabius and P. Decius established a law, by which it was ordained that every fifth year a procession of the equites should take place, and that those who had misconducted themselves should be degraded from their rank. They now evidently became a very powerful body in the state; yet in 186 B. C. we find it allowed as a reward to P. Æbutius, that the censor should not assign him a public horse, and thereby compel him to serve as an eques against his will. This proves that the duties must have been burdensome, and regarded by many with distaste. In the later times of the republic they increased in power and consequence, when the judicial functions were transferred from the senate to the body of equites by the Sempronian law, passed by C. Gracchus about 123 B. C.; and a short time afterwards they became the farmers of the public revenues, which enabled them to amass immense riches. Sylla deprived them of their judicial powers; but they now possessed too much influence in the state to be excluded from the higher and more dignified offices. After his death they were again admitted to their former power, which, however, they shared with the senate.

Towards the end of the republic, and under the emperors, the fortune requisite for an eques seems to have been four hundred sestertia, equal to about L.3229 of our money; and even at this time knights' horses were furnished by the state, as we find by ancient inscriptions of that period. (Gruter. *Inscrip.* 404.)

EQUITY, in a general sense, the virtue of treating other men according to reason and justice, or as we would be treated ourselves when we understand aright what is our due.

EQUITY, in jurisprudence, is defined to be a correction or qualification of the law, generally made in that part in which it either fails or is too severe. It likewise signifies the extension of the words of the law to cases unexpressed, yet having the same reason; so that where one thing is enacted by statute, all other things are enacted which are of the same degree.

EQUITY, in *Mythology*, sometimes confounded with *Justice*, a goddess amongst the Greeks and Romans, represented with a sword in the one hand and a balance in the other.

EQUIVALENT is understood of something that is equal in value, force, or effect, to another.

EQUIVALENT Terms, are where several words which differ in sound have yet one and the same signification; as *everybody was there*, and *nobody was absent; nihil non*, and *omne.*

EQUIVOCAL TERMS or WORDS, among logicians, are those which have a doubtful or double meaning.

EQUIVOCATION, the using a term or expression which has a double signification. Equivocations are expedients to avoid telling the truth, yet without telling a direct falsehood. Some of the fathers are great patrons of equivocations and mental reservations, and hold that the use of such shifts and ambiguities is in many cases allowable.

EQUULEUS, or ECCULEUS, in *Antiquity*, a kind of rack used for extorting a confession. At first it was chiefly practised on slaves, but was afterwards made use of against the Christians.

The equuleus was made of wood, with holes at certain distances, and provided with a screw, by means of which the criminal was stretched to the third, and sometimes to the fourth or fifth hole, while his arms and legs were fastened on the equuleus with cords, and thus hoisted aloft and extended in such a manner that all his bones were dislocated. In this state red-hot plates were applied to his body, and he was goaded in the sides with an instrument called an *ungula.*

EQUULEUS, EQUICULUS, and *EQUUS Minor*, the horse's head, in *Astronomy*, a constellation of the northern hemisphere.

ERA, in *Chronology*. See CHRONOLOGY.

ERAMNOO, an island at the entrance of the Gulf of Cutch, on the western coast of India, containing a town of the same name. Long. 68. 40. E. Lat. 22. 32. N.

ERANARCHA, a public officer among the ancient Greeks, whose business it was to preside over and direct the alms and provisions allotted for the poor. Cornelius Nepos, in his Life of Epaminondas, describes the office thus: When any person was reduced to poverty, taken captive, or had a daughter to marry, which he could not effect for want of money, the eranarcha called an assembly of friends and neighbours, and taxed each according to his means and estate, in order to contribute towards the relief of such person or persons.

ERASISTRATUS, a physician of Julis, a town of the island of Ceos, now Zea, off Cape Sunium, in Attica, who seems to have flourished from about 300 to 258 B. C. He was grandson of Aristotle, his mother being daughter of that philosopher. He seems to have been in high favour at the court of Seleucus Nicanor, whose son Antiochus he is said to have recovered from a dangerous illness in a somewhat extraordinary manner. Antiochus was violently enamoured of his mother-in-law Stratonice, but seeing no prospect of honourably succeeding in his desires, he determined to rid himself of life. His physician Erasistratus easily discovered that his distemper was love, but found it difficult to conjecture who was the object. By close observation however he soon perceived that Stratonice was the cause of his illness; and having informed his father, that monarch was so fond of his son that he allowed him to marry her.

In his old age he renounced the practice of medicine, and, retiring to Alexandria, devoted himself more particularly to the study of anatomy. His description of the brain and nerves is said to have been far more correct than that of any of his predecessors. He was the founder of a school of medicine, which flourished long at Smyrna, and the numerous disciples of which, under the name of Erasistei, continued to exist till the time of Galen, upwards of 400 years. He is mentioned in several passages of the ancient authors Suidas; Strabó, x. 486; Plutarch, *Demetr.* 38; Appian. *Syr.* 59.

ERASMUS, DESIDERIUS, was born at Roterdam on the 28th of October 1467.[1] His father, who bore the name of Gerard, was an inhabitant of Tergou; his mother, named Margaret, was the daughter of Peter, a physician of Sevenbergen. He had an elder brother, called Peter, but their parents were never married, though a promise of marriage is said to have preceded their intercourse. The brothers of Gerard, who was a young man of wit and gaiety, endeavoured to secure his patrimony by compelling him to become an ecclesiastic. Finding himself very uncomfortable in his own country, he went to Rome, where he employed himself in transcribing ancient authors; for the recent invention of printing had not entirely superseded this more slow and expensive method of multiplying copies of books. In the mean time, his relations sent him a false account of Margaret's death; and his grief for her supposed loss led him to adopt a resolution to which he could not be impelled by their importunities. Having taken orders, he returned to Holland, and found that she was still alive; but he could not now fulfil his promise of marrying her, and she never would marry another, nor did she continue to cohabit with him after he became a priest. He did not neglect the education of a son who was destined to reflect so much lustre on the age and nation to which he belonged. The boy was sent to school when he was only four years old; and, when he was still very young, his musical voice procured him a place among the choiristers in the cathedral church of Utrecht. At the age of nine he was removed to the school of Deventer, where his master was Alexander Hegius, and one of his school-fellows was Adrianus Florentius, who continued to be his friend when he was long afterwards elevated to the papal chair, under the name of Adrian the Sixth. At this early period, he exhibited uncommon powers of memory; and it has been said, perhaps with some degree of exaggeration, that he could repeat all Terence and Horace. His affectionate mother, who had likewise fixed her residence at Deventer, died of the plague when he was about thirteen; and his father, deeply affected with her loss, speedily followed her to the grave. They had both of them attained the age of about forty.

Gerard had recommended his hopeful son to the care of

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[1] Bayle, Dictionaire Historique et Critique, tom. ii. p. 1091. Several biographers refer the birth of Erasmus to the year 1465; but the inscription of his statue at Roterdam assigns the date of 1467.

Peter Winckel, master of the school of Gouda, and to that of other two guardians, but they all seem to have been alike unworthy of such a trust; for with the view of dividing his slender patrimony among themselves, they agreed to urge upon him the necessity of embracing the monastic state. They accordingly compelled him to betake himself to a convent of friars at Bois le Duc in Brabant, where, as he has himself stated, he lost three years of his existence. No artifice or persuasion could at first induce him to become a friar, nor did any length of time subdue his utter repugnance to a monastic life. Even at this early period, as has been well remarked, he could discern that religion was the thing least regarded in religious houses. He was afterwards placed in the convent of Sion near Delft; and having next been removed to that of Stein near Tergou, he reluctantly submitted to pass his year of probation, and to take the vows as a canon regular of St Augustin. His brother, who had likewise been devoted to the monastic profession, made an abrupt retreat from his convent, and led a profligate and dissolute life; but Erasmus, though he also quitted his monastic state, to which, as Du Pin observes, "he had no inward vocation," conducted himself with sobriety, and prosecuted his studies with great assiduity. In 1490 he left the monastery to reside in the household of Henry de Bergues, bishop of Cambray; and in 1492 he was ordained priest by the bishop of Utrecht. He had quitted the convent with the consent of the bishop, of the prior, and of the general of the order. He wore the habit as long as he conveniently could; but when he resided in Italy he was obliged to lay it aside, on account of its resemblance to the dress of those who attended persons infected with the plague. From Julius the Second he obtained permission to wear it or not, according to his own convenience, but on condition of still bearing some mark of his order; and from the same pope, or from his successor Leo the Tenth, he obtained an absolution from his monastic vows. For the name of Gerardi he had substituted that of Erasmus, as bearing a more classical form, with the same signification. This name is of a Greek origin, though its proper form is Erasmius; and, prefixing a Latin name of similar import, he adopted the appellation of Desiderius Erasmus, instead of Gerard Gerardi.

In the year 1496 he was prosecuting his studies in the university of Paris, where he became a member of the College of Montaigu, and was led to contract a friendship with our learned countryman Hector Boyce, afterwards principal of King's College, Aberdeen. The bishop of Cambray, who was more liberal of his promises than of his money, had undertaken to assist him with a small pension; but as he excited hopes which were never realized, Erasmus was left to the usual expedients of a scholar placed in such circumstances. He laboured very diligently to increase his own stock of learning, and endeavoured to earn his subsistence by taking private pupils: thus he gradually established a high reputation, and secured the friendship of individuals distinguished by their rank and influence, as well as by their talents and learning. One of his pupils was Lord Montjoy, in whom he found a steady friend, and who afterwards bestowed upon him an annual pension of a hundred crowns. It was apparently through his connexion with this young nobleman that he was induced to visit England. The plague drove him from Paris in the year 1497; and after passing through the Netherlands, where he was kindly treated by the marchioness of Vere in the castle of Tornenhens, he proceeded to London and Oxford. He now formed an acquaintance with John Colet, afterwards dean of St Paul's, and with Thomas Linacre, William Grocyn, and William Latimer, three individuals who each contributed to promote among their countrymen a more general taste for the elegancies of classical literature. He is said to have resided for some time in St Mary's College, Oxford; but not long afterwards we again find him at Paris, and he likewise appears to have visited Orleans. His *Enchiridion Militis Christiani* he had begun in 1494, at the castle of Tornenhens, but it was not completed till after an interval of several years. This little book became very popular, and was translated into various languages. An English version, ascribed to Tindall, was printed by Wynkyn de Worde in 1533.[1] About the same period he was preparing one of his most elaborate works, the *Adagia*, first printed at Paris in 1500, and was strenuously applying himself to the study of the Greek language. He mentions to one of his correspondents, that as soon as he could get any money, he would first purchase books, and afterwards clothes. He had already published several of his smaller tracts, and had laid the foundation of that celebrity which long continued to increase, and which that of very few modern scholars has exceeded. He had not however secured any adequate provision; and as he lived somewhat precariously, and wandered from one place to another, he was too frequently compelled to solicit the bounty of those to whom fortune had been more propitious.

It appears from his correspondence that he was occasionally residing in Paris in 1504 and the two succeeding years. To the study of the Greek language, to which he closely applied for the space of three years, he was induced to add that of the Hebrew; but, as Dr Jortin has remarked, "he soon grew tired of the attempt, in all probability for want of proper instructors and helps; else he did things infinitely harder than it is to learn Hebrew." The necessity of taking pupils interfered with his own plans of study, and prevented him from executing some literary projects which he had now formed. In 1506 he again made his appearance in England, and is then supposed to have visited Cambridge. During the same year, he returned to Paris, and took with him the sons of J. Baptista Boeria, first physician to Henry the Seventh. He next directed his course towards Italy; and while he was prosecuting his journey on horseback, he composed a poem on the infirmities of old age, and addressed it to William Cope, another physician. Although he had not completed his fortieth year, he considered himself as already numbered with the aged. His constitution had never been vigorous; and he was subject to various distempers, which his habits of unremitting application to study did not contribute to alleviate. At an earlier period of life, he had expressed some anxiety to visit Italy, in order to take a doctor's degree; which, as he was sufficiently aware, makes one neither better nor wiser; "but it must be done," says he, "if a man would be esteemed in the world." He accordingly took the degree of D. D. in the university of Turin. Having resided about fifteen months at Bologna, when he superintended the education of Boeria's two sons, he afterwards went to Venice, and there published a third edition of his Adages. He spent a winter at Padua, and repaired to Rome in the ensuing year. At Venice he contracted an acquaintance with Marcus Musurus and Scipio Carteromachus, who taught the Greek language at Padua and Bologna; and he availed himself of so favourable an opportunity of obtaining a solution of some of the difficulties which had occurred to him in the explication of Greek proverbs. It was at this period that he became the tutor of Alexander Stewart, a natural son of James the Fourth, by Margaret the daughter of Archibald Boyd of Bonshaw. His pupil, who was a youth of an amiable disposition and of promising talents, had been sent to the continent under the direction of Sir Thomas Halkerton, and, having travelled through France, became a student in the university of Padua; but it was at Sienna that he studied grammar and rhetoric under Erasmus, who has left a very pleasing account of his character, and who affectionately bewailed his premature death. At a very early age, he became archbishop of St Andrews, and obtained *in commendam* the abbacy of Dunfermline and the priorship of Coldingham. To these ecclesiastical preferments he added the office of lord chancellor; but having accompanied his father in the unfortunate expedition to England, he was slain, along with other warlike churchmen, at the battle of Floddon-field, before he had completed the twentieth year of his age.[1]

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[1] This was soon followed by another edition, printed by John Byddell, and bearing the following title: "Enchiridion Militis Christiani, whiche may be called in Englysshe the hansom Weapon of a Christen Knyght; replenyshed with many goodly and godly preceptes: made by the famous clerke Erasmus of Roterdame, and newly corrected and imprinted." Lond. 1534, 8vo. Many English translations from Erasmus are mentioned in Mr Lowndes's Bibliographer's Manual of English Literature, vol. ii. p. 673.

Erasmus experienced a gracious reception from the pope and some of the cardinals, but Rome had not sufficient attractions for a person of his disposition. We again find him in England about the beginning of the year 1510. On his arrival, he took up his abode with Thomas More, who was then a young man, and who afterwards rose to great eminence. It was at this period that he composed one of his most popular works, *Stultitiæ Laudatio*, or the Praise of Folly, which has been translated into all or most of the cultivated languages of Europe. In this lucubration, which he dedicated to his friend More, he treated the pope and the court of Rome with but little ceremony; so that, as Dr Knight has observed, "he was never after this looked upon as a true son of the church." The king, before the death of his father, had addressed a very friendly letter to Erasmus when he was in Italy, and he now received him with courtesy, although it does not appear that he ever bestowed upon him any very substantial proofs of kindness. To the king, as well as to Cardinal Wolsey, he owns himself indebted, not for magnificent benefits, but for magnificent promises. His chief patron was William Warham, archbishop of Canterbury, and chancellor of the kingdom; who, besides many occasional gratuities, bestowed upon him a living worth about a hundred nobles, the rectory of Aldington, near Ashford in Kent.[2] This however he speedily resigned, reserving to himself a yearly pension of twenty pounds; to which the archbishop added an equal sum from his own purse. He was invited to Cambridge by Dr Fisher, bishop of Rochester, president of Queen's College, and chancellor of the university, who entertained him in his own house, and procured him the appointment of Lady Margaret's professor of divinity, and that of Greek professor. Of these offices however, the honour appears to have exceeded the emoluments, nor did he long continue his residence at Cambridge. In the Greek chair he was succeeded by Richard Croke, who had previously taught that language in the university of Leipzig. His treatment in England reflects no particular credit on the character of those who had the chief distribution of ecclesiastical preferments. The king, though capable of perceiving his merit, had not sufficient generosity to reward it; and the lordly churchmen reserved their best benefices for those who had other recommendations to their protection and favour. He has himself stated that if the promises made to him had been realized, he would have spent the remainder of his days in England; but having been invited to Brabant, to the court of Charles archduke of Austria, he again returned to the Netherlands, where he appears to have been residing in the beginning of the year 1514. With the honorary title of counsellor to that prince, he obtained an annual pension of two hundred florins, which, if it had been regularly paid, would have placed him in circumstances sufficiently easy. He was presented to a canonry at Courtray, but this he likewise resigned, reserving to himself a pension out of its yearly revenue.

He had for some time been laboriously employed in preparing an edition of the Greek Testament; and in the course of the same year he proceeded to Basel, for the purpose of printing it at the celebrated press of Froben. He likewise carried with him the epistles of St Jerom, illustrated with his notes, and some other books intended for publication. To the writings of this father he had devoted much attention, and, on his arrival, he was therefore gratified to find that an edition of his works had already been sent to the press. His edition of the New Testament was first printed in 1516; and other editions issued from the same press in 1519, 1522, and 1527. At Basel he now spent several months, much to his satisfaction, and was particularly gratified with the reception which he experienced from the bishop of that see. Returning to the Netherlands, he learned that Charles, who afterwards became emperor of Germany, had nominated him to a vacant bishopric in Sicily, supposing it to be at his own disposal; and, finding the right of nomination belonged to the pope, that he had solicited this preferment for Erasmus. But the recommendation, which perhaps was not very urgent, failed to produce any effect; nor did he hear of any effort to procure him a bishopric, where the patronage was more free from entanglement. In the year 1515, he appears to have paid another visit to Basel, and likewise to England. To this country he made another excursion in 1517. Of the domestic habits of the English, he has drawn a picture which now seems not a little antiquated. The plague, from which that country was scarcely ever free, and the sweating sickness, he partly ascribes to the incommodious form and bad exposition of the houses, to the filthiness of the streets, and to the sluttishness within doors. "The floors," says he, "are commonly of clay, strewed with rushes, under which lies unmolested an ancient collection of beer, grease, fragments, bones, spittle, excrements of dogs and cats, and every thing that is nasty."

Francis the First had invited him to fix his residence in France, and had promised him a benefice of a thousand livres; but of this offer he could not be induced to avail himself. He still lingered in the Netherlands; and we find him occasionally residing at Louvain, the seat of a university which was long conspicuous for the bigotry of its theologians, some of whom had appeared as his professed antagonists.[3] An event of great moment in the history of mankind was now impending. In the memorable year 1517, the reformation of religion in Germany began by Luther's bold and decided opposition to the scandalous traffic in indulgencies; one of the most corrupt practices of a most corrupt church. From this beginning, apparently trivial, arose many important events; and although Erasmus did not possess the undaunted spirit of a genuine reformer, his writings were not without considerable influence in preparing the way for those salutary changes which now began to take place. The edge of his wit and ridicule was very sharply directed against monastic ignorance and grimace, against the vain observances which were so generally substituted for real piety.[1] Many of his publications had a powerful tendency to promote a critical knowledge of the Scriptures and of ecclesiastical antiquity, and consequently were opposed, though indirectly, to the cause of popery. But he never had the courage to avow his adherence to the cause of reformation; and he himself admitted that he was not endowed with the spirit of a martyr.[2] He was sufficiently ready to condemn the heat and violence of the German reformer: but the task undertaken by Luther was not to be executed by a man of a cool and balancing disposition; and without a large portion of his unflinching impetuosity and undaunted resolution, his disputation and his preaching would, to all human appearance, have been utterly unavailing. No sudden and beneficial change in the affairs of mankind will ever be effected by those who, like Erasmus of Roterdam, keep themselves aloof from all danger, and recommend gentleness and moderation to others, when they have to contend against temporal power, fortified by inveterate prejudice, and roused by the most intense feelings of selfishness.[3] He was however very far from approving of the violent proceedings of Luther's adversaries. In the year 1520, he was consulted at Cologn by Frederick elector of Saxony, and gave a very favourable opinion of the reformer. Luther, he remarked, has been guilty of two offences; he has touched the crown of the pope and the bellies of the monks. He added, in a more serious strain, that he had justly censured many abuses and errors, which it was necessary to reform and correct; that his doctrine was essentially right, but that it had not been delivered with a proper temper, and with due moderation. Although his conduct did not fully satisfy the Lutherans, it still less satisfied the papists. The publication of his *Colloquia* did not contribute to recommend the author to the genuine sons of the Romish church: it exposed him to new accusations of laughing at indulgencies, of disregarding auricular confession, and of deriding the pious use of fish, instead of flesh, on certain appointed days. This book, the most popular of all his performances, was published at Basel: an impression, said to consist of twenty-four thousand copies, was printed in 1527 by Colinet at Paris, and dispersed with amazing rapidity. The sale was promoted by a rumour, which is supposed to have been circulated by the printer, that the work was on the point of being suppressed. During the preceding year, the theological faculty of Paris had censured it as a book in which the fasts and abstinences of the church are slighted, the suffrages of the holy virgin and the saints are derided, virginity is placed below matrimony, Christians are discouraged from a monastic life, and grammatical is preferred to theological erudition. In the year 1549 a provincial council, held at Cologn, condemned the Colloquies of Erasmus as unfit to be read in schools.

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[1] Crawfurd's Lives of the Officers of State, p. 59. Edinb. 1726, fol.

[2] Knight's Life of Erasmus, p. 154. See Dr Middleton's Free Inquiry, p. cxxvi.

[3] Beatus Rhenanus mentions his having taught at Louvain. "Docuit Lovanii, Cantabrigiæ in Anglia, Lutetiæ etiam privatim, ubi theologiæ dedit juvenis operam." Erasmus, in his short account of his own life, has stated that he went to Louvain after he first returned from England.

The latter years of his life he spent in Switzerland, chiefly at Basel and Friburg. In the summer of 1522 he paid a visit to Constance, professing an intention of repairing to Rome, for the purpose of waiting upon his old school-fellow the new pope; but to one of his correspondents he mentions that he had fallen sick at the former city, and was deterred by rumours of war from prosecuting his journey. It is however more than probable that he had no great inclination to proceed. Adrian offered him a good deanery, which he did not think it advisable to accept; for he apparently considered it in the light of a retaining fee from the pope. In Switzerland he had many friends, and was only prevented from liking the country by the suffocating heat of the stoves, and the bad quality of the wine. Being subject to the stone and gravel, he found the new and acid beverage unsuitable to his constitution, and was obliged to procure wine from Burgundy. As he kept two servants and two horses, it may be inferred that he was enabled to live in sufficient comfort.

Ulrich von Hutten, a distinguished adherent of Luther, passing through the city of Basel in 1522, solicited an interview, which the caution of Erasmus prevented him from granting.[4] A slight of this nature was more than sufficient to rouse the vehement indignation of the German knight, who speedily discharged his spleen in a publication entitled "Ulrici ab Hutten cum Erasmo Roterodamo, Presbytero, Theologo, Expostulatio." This satirical effusion was followed by the "Spongia Erasmi adversus Aspergines Hutteni." Hutten's insolence and ferocity were blamed by Melanchthon, and by Luther himself.

In the year 1523, Adrian was succeeded in the papal chair by Clement the Seventh, who sent Erasmus an honourable epistle, accompanied with a donation of two hundred florins. After many solicitations from different quarters, he was at length induced to write against Luther, but not on a subject which involved the chief points of debate between the protestants and papists. His tract *De Libero Arbitrio* was printed in the year 1524. "Luther," says Dr Jortin, "was an admirer of Augustin, and, like the Thomists, held a physical predetermination, which entirely subverts human liberty, and which, under the pretence of making the creature dependent upon the Creator, deprives it of all active powers, so that it can do nothing without being necessarily determined by the influence of God. If there was any difference between Luther and the Thomists of the church of Rome, it was this, that Luther spake more simply and sincerely and openly than they; for he absolutely denied that there was any such thing as free-will, whilst they admitted it in words. This perhaps deceived Erasmus, who imagined that he was only disputing against Luther, whilst he was really disputing as much against Thomas Aquinas and his followers, as against the reformer. Be that as it will, Erasmus makes many good remarks against the sentiment which he opposes, and justly insists upon it, that the human will co-operates with the grace or assistance of God."[5] In 1525 Luther returned an answer, in a treatise *De Servo Arbitrio*, where his antagonist is treated with much scorn and contempt. Erasmus immediately replied in the first part of his *Hyperas-*

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[1] Dr Robertson has remarked that "there was hardly any opinion or practice of the Romish church which Luther endeavoured to reform, but what had been previously animadverted upon by Erasmus, and had afforded him subject either of censure or raillery." (Hist. of Charles V. vol. ii. p. 142.) See likewise Archdeacon Blackburne's Confessional, p. 409. The worthy archdeacon describes Erasmus as "one of the most illustrious characters in all history."

[2] J. A. Fabricius has written a tract on the religion of Erasmus, which may be found in his *Opusculorum historico-critico-literariorum Sylloge*, p. 357. Hamb. 1738, 4to.

[3] "As the man," says Dr Paley, "who attacks a flourishing establishment writes with a halter round his neck, few ever will be found to attempt alterations but men of more spirit than prudence, of more sincerity than caution, of warm, eager, and impetuous tempers; consequently, if we are to wait for improvement till the cool, the calm, the discreet part of mankind begin it, till church governors solicit, or ministers of state propose it—I will venture to pronounce that (without His interposition with whom nothing is impossible) we may remain as we are till the renovation of all things." (Sermons and Tracts, p 43.)

[4] See Schubart's Leben und Charakter Ulrichs von Hutten, S. 131. zweit. Ausg. Leipzig, 1817, 8vo.

[5] Jortin's Life of Erasmus, vol. i. p. 335.

pistes, and the second part appeared in the year 1527; but, upon the whole, he appears to have had no reason to congratulate himself on the issue of the controversy.

About this period, Erasmus prepared various other works. In 1525 he published "Lingua, opus novum, et hisce temporibus aptissimum." In 1528 he published, in one volume, two of the most conspicuous of his literary compositions. The first bears the title, "De recta Latini Græcique Sermonis Pronuntiatione Dialogus;" the second, "Dialogus cui titulus, Ciceronianus, sive de optimo Genere Dicendi." Both these works were printed at Basel. His dialogue on the pronunciation of the classical languages excited much attention, and occasioned much controversy.[1] The pronunciation of Greek which then prevailed, was in some countries denominated the Reuchlinian, from its having been adopted by Reuchlin, who died in the year 1521, after having been chiefly instrumental in the introduction of classical learning into Germany. It essentially coincided with the pronunciation of the modern Greeks. In the copious grammar of Scot,[2] first printed in the year 1593, we still find the same system recommended. To the letter β he assigns the name of vita, to ζ of zita, to η of ita, to θ of thita. According to this system, the vowels η, ι, υ, and the diphthongs ει, οι, have no variety of sound, but ought to be pronounced as the French pronounce the letter *i*. Thus τη, τι, τυ, τει, τοι, have one and the same sound, instead of five distinct sounds. This however is not the only peculiarity of the system. Reuchlin's mode of pronunciation was almost entirely supplanted by that of Erasmus, although several learned men have at a much more recent period endeavoured to restore the old method. In his other ingenious dialogue, the *Ciceronianus*, he ridicules some modern scholars, chiefly Italians, who studiously rejected every word or phrase which had not been sanctioned by the authority of Cicero. Of the dead and the living he speaks with his usual freedom; nor did this publication contribute to diminish the number of his enemies. It was attacked with great ferocity by Julius Cæsar Scaliger, who writes in a style by no means Ciceronian.

In the year 1529, after the mass had been abolished at Basel, he removed to Friburg, where he purchased a house, and repaired it at considerable expense. In 1533 he published at Antwerp a treatise bearing the title of "Liber de sarcienda Ecclesiæ Concordia." On the same subject, he has introduced many suggestions into his epistles; but the peace of the church was not to be patched up by any expedients which Erasmus was capable of devising. His "Ecclesiastes, sive de Ratione Concionandi," appeared in 1535; and while it was printing at Basel, he returned to that city, and there he completed his earthly pilgrimage. On the accession of Paul the Third, a design was entertained of elevating Erasmus to the rank of a cardinal; but he had never been ambitious of ecclesiastical dignities, and now the state of his health was such as to deprive all sublunary honours of their usual attractions. The pope nominated him provost of the college of canons at Deventer; but already considering himself as standing on the verge of the grave, he declined an office which he probably would not have accepted in the vigour of his life. He had left Friburg in a bad state of health, nor were his maladies alleviated by his removal to Basel. He became worse during the summer, and for about a month was afflicted with dysentery. Disregarding those formal and minute devotions which he had so much derided in the monks, he fervently implored the mercy of God through Jesus Christ; and retaining his reason unimpaired till his last moments, he calmly expired on the 12th of July 1536, when he had nearly completed the sixty-ninth year of his age. A great concourse of people attended his funeral in the cathedral church of Basel. By his will, dated in the month of February, he bequeathed handsome legacies to several of his friends, and directed the residue of his property to be distributed by his executors, in relieving the poor and the sick, in marrying young women, and in assisting young men, such as they should judge to be necessitous and deserving.

Erasmus, though somewhat low in stature, was well formed, and had an easy and genteel air, nor was he slovenly or negligent in his apparel. He had a fair complexion, with grey eyes, and, during his youth, his hair was of a pale yellow. He had a cheerful countenance, with a low voice, and a pleasing elocution. He was a steady friend, and an agreeable companion; and indeed if his conversation displayed any portion of the wit and vivacity which distinguish his writings, his society could not fail of being delightful. Ardently devoted to letters, he kept his mind uncontaminated with that avarice and ambition by which churchmen have in too many instances been secularized. In disseminating a love of elegant letters among his contemporaries, he had no small influence, and equally conspicuous were his merits as a theologian. For the lifeless formalities of scholastic theology he had little respect, and less relish; but by his labours on the New Testament, and more especially by his publication and elucidations of the original text, he gave a new impulse to the students of that age, and directed their minds to a more edifying species of knowledge. To him belongs the honour of being the earliest editor of the Greek Testament; for although the Alcala edition, inserted in the Polyglot Bible, bears the imprint of 1514, it was not published till the year 1522. Of his paraphrase of the New Testament, an English translation was printed at an early period;[3] and so high was the estimation in which it was held, that a copy of it was directed to be placed in every parish-church in the kingdom.[4] The works of the ancient fathers of the church he had studied with much assiduity. To editions of Irenæus, Chrysostom, Cyprian, Hilary, Ambrose, Jerom, Augustin, and Arnobius the younger, he contributed more or less aid; and he translated particular treatises of Origen, Athanasius, Basil, and Chrysostom. His labours likewise served to render the writings of the ancient classics more accessible. Of the Geography of Ptolomy, the Greek text was first edited by Erasmus. He published editions of Livy, Seneca, Suetonius, and other authors; and if he seldom added notes, his prefaces were considered as no small recommendation. He translated into verse the Hecuba and Iphigenia of Euripides, and into prose detached works of Galen, Plutarch, Lucian, and Libanius. The labours of Erasmus were multifarious, and his compositions are very numerous; for our scanty limits have only afforded us an opportunity of specifying the more remarkable. An ample and elegant edition of his works was published by Le Clerc, to whom we are likewise indebted for a discriminating account of the author's life and character.[1]

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[1] Of this famous controversy a detailed account may be found in the Foreign Quarterly Review, vol. xiii. p. 60.

[2] Alexander Scot, LL. D. was a native of Scotland, but he appears to have spent the greatest part of his life in France, and to have exercised the functions of a judge at Carpentras. "Alexander Scotus Aberdonensis, magni nominis, sed majoris meriti, utriusque linguæ peritus, juris civilis scientia in paucis clarus, Carpentoractensis præfectus juri dicundo, quo in munere non minorem integritatis quam eruditionis famam acquisivit." (Dempsteri Historia Ecclesiastica Gentis Scotorum, p. 664.) We use the third edition of his *Universa Grammatica Græca*. Lugduni, 1614, 8vo. This is not the only work which Scot published.

[3] Lond. 1548-9, 2 vols. fol. The translation was executed by Miles Coverdale, Nicholas Udall, John Olde, and others. See Dr Dibdin's Typographical Antiquities, vol. iii. p. 491.

[4] Burnet's History of the Reformation, vol. ii. p. 27.

Dr Jortin has remarked that "the style of Erasmus is that of a man who had a strong memory, a natural eloquence, a lively fancy, and a ready invention, who composed with great facility and rapidity, and who did not care for the trouble of revising and correcting; who had spent all his days in reading, writing, and talking Latin; for he seems to have had no turn for modern languages, and perhaps he had almost forgotten his mother tongue. His style therefore is always unaffected, easy, copious, fluent, and clear, but not always perfectly pure, and strictly classical. He hath been censured, as a dealer in barbarisms, by persons who not only had not half of his abilities and erudition, but who did not even write Latin half so well as he. His verses are plainly the compositions of one who had much learning and good sense, and who understood prosody, or the technical part of poetry, but who had not an equal elegance of taste, and an ear for poetical numbers. So that upon the whole he is rather a versifier than a poet, and is not to be ranked amongst the Italian poets of those days, Sannazarius, Fracastorius, Vida, &c. many of whom wrote better than any of the ancients, except Lucretius, Virgil, Horace, and a few more." (x.)

ERASTIANS, a religious sect or faction which arose in England during the time of the civil wars in 1647, and were so called from their leader Thomas Erastus, whose distinguishing doctrine it was, that the church had no right to discipline, that is, no regular power to excommunicate, exclude, censure, absolve, decree, or the like.

ERATO (from *εϱαω*, *I love*), in *Mythology*, the name of one of the nine muses, who presided over amatory poetry. To this muse some have ascribed the invention of the lyre and the lute. She is represented with a garland of myrtles and roses, holding a lyre in one hand and a bow in the other, and at her side is a Cupid with his torch. There is also a Nereid of the same name.

ERATOSTHENES, the son of Aglaus, was born at Cyrene, on the northern coast of Africa, 275 B. C., and died at the advanced age of eighty, 194 B. C. We are told by Suidas that he studied under the philosopher Aristo of the island Chios, the grammarian Lysanias of Cyrene, and the poet Callimachus, whilst Strabo mentions that he received instruction from Zeno the Citian. He was invited from Athens by Ptolemy Euergetes to take charge of the celebrated library at Alexandria; and here he continued to reside under the successors of this prince, till, having lost his sight from old age, he put an end to his life by means of hunger. Though the ancients were divided in their opinions respecting his merits, there is good reason to believe that he was a man of distinguished talent, and intimately acquainted with the whole circle of science then known to the world. He was a geometer, astronomer, geographer, philosopher, grammarian, and poet, and left works behind him in each of these departments; but they have all disappeared in the lapse of ages. It is in geography that he seems to have been most distinguished; the first two books of Strabo are almost entirely occupied with an examination of his system, and a correction of some of the errors into which he had fallen respecting the western parts of Europe. We do not think that Strabo does full justice to Eratosthenes, expecting more accuracy than the state of geographical knowledge in that age would warrant. But all later writers, including Strabo himself, borrowed largely from him; and where they have ventured to correct his observations, they have only more clearly proved their ignorance of the subject. Thus Eratosthenes is nearer the truth in respect to the length of the Mediterranean from Gibraltar to Sicily than Polybius, who found fault with him. The fragments of his works have been collected and published at Oxford in one vol. 8vo; also by Seidel, Göttingen, 1789, and *Eratosthenica*, by Bernhardy, Berlin, 1822. For a list of his works, see Clinton's *Fasti Hellenici*, vol. ii. p. 513.

ERATOSTRATUS, an Ephesian who burned the famous temple of Diana, the same night on which Alexander the Great was born. This burning, as some writers have observed, was not prevented or seen by the goddess of the place, who was then present at the labour of Olympias, and at the birth of the conqueror of Persia. Eratostratus committed this crime merely to eternize his name by a memorable though infamous action.

ERBIL, a town of Persia, in the pachalic of Bagdad; the ancient Arbela, where Alexander the Great defeated Darius. It is situated on an eminence commanding an extensive plain, which abounds in grain and fruit. It is surrounded by walls, but is now a poor place, containing about 2000 or 3000 Kurds or Chaldeans. It is sixty miles east of Mosul. Long. 43. 20. E. Lat. 36. 11. N.

EREBUS, Εϱεϐος (from ערב, *night*), in *Mythology*, a term denoting darkness. According to Hesiod, Erebus was the son of Chaos and Night, and the father of the day. This was also the name of part of the *inferi* among the ancients; and a peculiar expiation was provided for those who were detained in Erebus.

Erebus was properly the gloomy region, and distinguished both from Tartarus the place of torment, and Elysium the region of bliss. According to the account given of it by Virgil, it forms the third grand division of the invisible world beyond the Styx, and comprehends several particular districts, as the *limbus infantum*, or the receptacle for infants; the *limbus* for those who had destroyed themselves; the fields of mourning, full of dark groves and woods, inhabited by those who died for love; and beyond these, an open champaign country for the accommodation of departed warriors.

ERDING, a bailiwick in the circle of the Isar, in the kingdom of Bavaria, extending over 308 square miles. It contains three large and fifty-six small towns, 262 villages, and 6632 dwelling-houses, with 28,370 inhabitants. The chief place, of the same name, is a walled town situated on the river Sempt, containing 275 houses and 1890 inhabitants, employed in various trades. Long. 11. 49. 48. E. Lat. 48. 18. 23. N.

EREKLEE, a town of Asiatic Turkey, in the province of Caramania, situated on the left bank of the river Kalys, in the centre of a fertile country. It stands in front of a hill, and, though it is of considerable size, has a mean appearance, the houses being constructed of mud, with sun-dried bricks. The gardens yield much fruit, especially pears. It is said to be the ancient Heraclea. Long. 34.

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[1] Desiderii Erasmi Opera omnia emendatiora et auctiora. Lugd. Bat. 1703-6, 10 tom. fol. Le Clerc's account of Erasmus, chiefly derived from his letters, may be found in the *Bibliothèque Choisie*, tom. v. p. 145, tom. vi. p. 7. His other biographers are numerous; and we shall mention the most considerable lives which have appeared in a separate form. Knight's Life of Erasmus, more particularly that part of it which he spent in England. Cambridge, 1726, 8vo. Burigny, Vie d'Erasme. Paris, 1757, 2 tom. 12mo. Jortin's Life of Erasmus. London, 1758-60, 2 vols. 4to. Hess's Erasmus von Roterdam nach seinem Leben und Schriften. Zürich, 1790, 2 Bde. 8vo. Of M. de Burigny's work, a German translation, with corrections and additions, was published by Professor Henke. Halle und Helmstädt, 1782, 2 Bde. 8vo. Dr Knight's work had been translated into the same language by Theodor Arnold. Leipzig, 1735, 8vo.

34. E. Lat. 37. 30. N. This is also the name of a seaport in Asiatic Turkey, situated on the Black Sea. It is 100 miles east of Constantinople.

EREMIEU, a town of the department of the Isère, in France. It is surrounded with walls, and was the former residence of the dauphin or sovereign of Dauphiné. It contains 590 houses, and 2184 inhabitants, who are chiefly employed in making hempen cloth.

EREMONVILLE, a village in the department of the Oise, in France, containing 470 inhabitants. It is celebrated on account of a palace built by Henry IV. for his fair favourite Gabrielle, and afterwards the residence of Rousseau.

ERETRIA, a city on the western coast of the island Eubœa, founded along with Chalcis by a colony of Athenians, who were afterwards joined by a band of Æolians from Elis. Its extensive commerce raised it to considerable eminence at an early period; it founded colonies in the peninsula of Pallene, and also at Cumæ in Italy. It had under its dominion many of the neighbouring islands, as Andros, Ceos, and Teos, and was for many years the rival of the neighbouring city of Chalcis. Strabo (x. 448) states, as a proof of the wealth of the ancient inhabitants, that the festival of the Amarynthian Diana was often attended by 3000 soldiers on foot, with 600 cavalry and sixty chariots.

Eretria assisted the Ionians in their attempt to shake off the yoke of the Persian king, and was on that account exposed to the vengeance of Darius. It withstood for six days all the forces that could be brought against it; but it was at last betrayed into the hands of the enemy by the treachery of two of its principal citizens. The city was destroyed, and the inhabitants transported to Susa, whence Darius sent them to settle in the country of the Cissæi (Herodot. vi. 99, 119). Those inhabitants who had escaped rebuilt the city in a somewhat more northerly direction, as soon as the Persians had been compelled to retire. From this time it seems to have been subject to the Athenians, and to have continued in so peaceful a condition, that many of the learned, anxious to escape from the tumults of war, selected it as their residence. In later times it attached itself to the cause of Philip III. of Macedonia, and was on that account attacked by the Romans and plundered of all its statues and works of art (Liv. xxxii. 16). After the conquest of Greece by the Romans, it was declared free; but it never recovered from the blow it had received (Polyb. xviii. 28). Its ruins are to be found near a promontory which is situated opposite to the mouth of the river Asopus in Bœotia.

ERFURT, a city of the Prussian province of Saxony, and the capital of a circle of its own name, as well as of the provincial government. It is strongly fortified, and is defended by two forts, the Petersburg and the Cyrialsburg, both of most skilful construction. It is situated in a district of peculiar fertility, especially in garden fruits and seeds, the latter of which supply the seedsmen in distant parts of Germany. It sells large quantities of annis, canary, coriander, cummin, mustard, and poppy seeds; and much surplus corn. There was formerly a university, but it has declined, as well as most of the convents and monasteries which existed before its secularization. It now possesses a gymnasium and elementary schools, as well as many charitable establishments. It is a clean and well-built city, containing an ancient cathedral, with a lofty spire, and a bell weighing fourteen tons; eight Catholic and eight Lutheran churches, 2897 houses, and (in 1817) 18,218 inhabitants, now much increased in number. There have been lately erected some cotton spinning-mills; and other manufactures have since the peace very greatly extended. Being on the great road from Frankfort to Dresden and Leipsic, it has a considerable transit trade. Long. 11. 57. 17 E. Lat. 50. 59. 8. N.

ERGASTULUM, amongst the Romans, was a prison, work-house, or house of correction, where slaves were by the private authority of their masters confined and kept to hard labour for their offences. The Greeks had a place of confinement of the same sort.

ERIDANUS, a river celebrated in *Mythology* for the fall of Phaethon, and the metamorphosis of his sisters into long and slender poplars. Astronomers placed Eridanus in the heavens, and made it one of the southern constellations. It was supposed to be the ancient name of the river Po, but the difficulty of explaining the tradition of amber being gathered on its banks has excited doubts respecting the correctness of this information. Cluverius has suggested that the Eridanus of Herodotus may be the *Rhodaune*, a tributary of the Vistula; whilst others, knowing that amber was the staple product of the Baltic, are inclined to believe it the name of that sea, applied to it by mythologists, who were little acquainted with geography. (Virg. *Georg.* i. 412; *Æn.* vi. 659.)

ERIDANUS, in *Astronomy*, a constellation of the southern hemisphere, supposed to have the form of a river.

ERIE, a great lake of North America. It is about 280 miles in length from south-west to north-east, from ten to sixty-three in breadth, and about 658 in circumference. It has a depth of 120 feet; and its surface, which contains 12,000 square miles, is elevated 334 feet above that of Lake Ontario, with which it is connected by a canal, and 565 feet above the tide water at Albany, with which it is joined by the great Erie Canal. Through this immense sheet of water runs the boundary line which separates Canada from the United States. On its northern shore there are numerous projecting rocks, which render the navigation dangerous, particularly as there is no shelter from storms in that quarter. On the southern shore, however, there are several tolerably good harbours. The lake is navigated by a number of steam-boats, which of course are continually increasing in number, as civilization advances and commerce extends. The navigation upwards is rendered tedious, on account of a constant current which sets down the lake; and this is increased by the north-western and south-western winds, which here prevail. Long. 78. 35. to 83. 10. W. Lat. 41. 20. to 42. 50. N.

ERIGENA, JOANNES SCOTUS, a famous scholastic divine, was born about the beginning of the ninth century; but where, is a matter of dispute among authors. Bale and Pitts affirm that he was born at St David's in Wales; Dempster, Mackenzie, and Henry, that he was a native of Scotland. Dempster contends that he was born in Ayr, and in order to suit the name to the hypothesis, he describes him as Joannes Airigena. Du Pin, Sir James Ware, and Dr Ledwich have with greater probability asserted that he was by birth an Irishman, Ireland being in those days called *Scotia*, and by the natives *Erin*. Various writers agree in relating that he travelled to Athens, where he acquired a competent knowledge of the Greek and oriental languages; and that he afterwards resided many years in the court of Charles the Bald, king of France, who, on account of his singular abilities, treated him as his intimate friend and companion. He slept frequently in the royal apartment, and was constantly admitted to the king's table. "We may judge," says a modern historian, "of the freedom which he used with Charles, by the following repartee. As the king and Scotus were sitting one day at table, opposite to each other, after dinner, drinking a cheerful glass, the philosopher having said something that was not quite agreeable to the rules of French politeness, the king in a merry humour asked him, Pray, what is between a *Scot* and a *sot?* To which he answered, "Nothing but the table."[1] During his residence with Charles, he wrote several books of scholastic divinity, and was not so fortunate as to escape the imputation of heterodoxy. On that account the pope commanded Charles to send him to Rome, but the king had too great a regard for his companion to trust him with his holiness. One of the chief controversies in which Erigena was engaged, and with which the pope was much offended, was concerning the real presence. His opinion of this weighty matter is expressed in these few words: " What we receive corporally is not the body of our Lord, but that which feeds the soul, and is only perceived by faith."

Whether Erigena ended his days in France is a matter of doubt. Some of our historians tell us that he quitted it in the year 864; and that, after residing about three years in Oxford, he retired to the abbey of Malmesbury, where his scholars stabbed him with their pen-knives. There is no foundation for this story. Probably he died about the year 874; but whether in France or England, is uncertain, and of little importance. Some have related that he was invited to England by King Alfred; but they have apparently confounded him with John abbot of Etheling, who was assassinated in 895; and to this mistake the various accounts concerning Erigena are to be attributed. Besides many other works, he composed the following. 1. *Excerpta de Differentiis et Societatibus Græci Latinique Verbi.* 2. *De Divisione Naturæ lib. v.* 3. *De Prædestinatione Dei.* 4. *De Visione Dei.* 5. *De Corpore et Sanguine Domini.* 6. *Ambigua S. Maximi, seu Scholia ejus in difficiles locos S. Gregorii Nazianzeni, Latine versa.* 7. *Opera S. Dionysii quatuor in Latinam linguam conversa.* Most of these works have been printed. There is an edition, somewhat recent, of his books *De Divisione Naturæ.* Oxon. 1681, fol. The author was formerly denominated the Glory of the Greeks; an appellation to which, in the opinion of Montfaucon, he was not sufficiently entitled.[2] For the age in which he lived, he however appears to have been a person of eminent learning; and his translation of Dionysius Areopagita has received no mean commendation from Huet.[3]

ERIGONE, in fabulous history, daughter of Icarus. She died of grief on account of her father's death, was translated into heaven, and formed the sign Virgo.

ERITH, a town of the county of Kent, in the hundred of Lessness and lathe of Sutton, fourteen miles from London. It stands on the right bank of the Thames. It is chiefly inhabited by fishermen and other seafaring people; but Belvedere House, on the site of an ancient monastery, is one of the most striking objects to passengers in vessels ascending or descending the Thames. The population amounted in 1801 to 969, in 1811 to 1119, in 1821 to 1363, and in 1831 to 1533.

ERIVAN, a province of Persia, bounded on the north and west by the Mossian Hills, on the south by the Araxes, and on the east by the districts of the Karabang and Karadang. It is of considerable extent, and has a salubrious climate, though the winter is of long duration. It possesses, according to Sir R. K. Porter, by whom it was visited in 1817, every natural beauty which a fine assemblage of mountain, dale, and water can bestow. The principal towns are Erivan and Nackshivan. This province is ruled by a sardar, who differs from most others in the empire, as he pays no tribute to the king, holding his station by a military tenure, by which he is bound to furnish to the royal army in time of war a certain quota of troops. To him is entrusted the defence of the frontier within the limits of the province; so that he more resembles a prince in his authority, as well as in all his appointments, than a provincial governor. He has immense wealth both in money and in land. The province is 200 miles in length and 100 in breadth. According to a general census taken in 1814, the number of inhabitants capable of bearing arms amounted to 18,000. The annual revenue is 150,000 tomauns, or L.75,000 sterling.

ERIVAN, *Irwan*, or *Irivan*, the capital of the above province, situated in an angle of a great plain at the foot of the Mossian Hills, on the banks of the river Zengui, which rises from a lake about seventy miles farther north, and falls into the Araxes about three leagues below the town. It is defended by a fortress of an elliptical form, upwards of 6000 yards in circumference. The city is of considerable extent, but, as generally happens in Persia, ruins mingle everywhere with the habitable parts of the town. The north-west side of the town is built on a precipice impending over the river, to the height of 600 feet. The fortress spreads over a great deal of ground. It is fortified in the mixed ancient and modern Asiatic manner; and has been lately strengthened by European engineers. But it is commanded on every side by hills at a distance of scarcely 6000 yards. The Zengui flows close past the north-west front, which is on the summit of a perpendicular rock seventy feet deep, forming a natural ditch. " Nothing," says Sir R. K. Porter, " can exceed the grandeur of these bulwarks of nature, which so frequently present themselves around fortified places in those precipitous countries; their vastness, simplicity, and impregnable appearance being far beyond the powers of man to imitate." The walls of Erivan, with their numerous towers, make a line of defence exceeding 2000 yards. Immediately beyond them a fine stone bridge crosses the river, which is almost the only object in the town that does not appear in a state of ruin or decay. Erivan has been so often the scene of devastation, plunder, and massacre, that the population has dwindled to about 15,000 persons. The singular old tower described by Chardin being struck with lightning and greatly damaged, has been pulled down, and the materials appropriated to the repairs of the town. The city is well supplied with water from the little river Querk-boolak, which has its source in the great lake, and runs thence north-east, but on approaching the city is divided into numberless little canals for the irrigation of the surrounding gardens, or for other purposes. Sir R. K. Porter supposes that the Erivan was founded sixty-five years before the Christian era, by Ervandus, one of the Armenian kings. In 1635 it was taken from the Turks by the Persians, and its position changed to its present site. It was besieged in 1724 by the pasha of Diarbekir, who in four successive attempts to storm it lost about 24,000 men. It afterwards capitulated, after a brave defence. It was taken by Nadir Shah in 1748, and has since remained in possession of the Persians. In 1808 it was blockaded for six months by the Russians, who, in attempting to storm, were repulsed with great slaughter, and lost half their army in its retreat to Tiflis. It was taken by them in 1829, and given up to Persia by the subsequent treaty of peace. Long. 44. 35. E. Lat. 40. 9. 30. N.

ERIPHYLE, in fabulous history, a sister of Adrastus king of Argus, who married Amphiaraus. She was daughter of Talaus and Lysimache. When her husband concealed himself in order that he might not accompany the Argives in their expedition against Thebes, where it had been predicted he was to perish, Eriphyle suffered herself to be bribed by Polynices with a golden necklace which had been formerly given to Hermione by the goddess Venus, and discovered where Amphiaraus lay hidden. This treachery of Eriphyle compelled him to go to the war; but before he departed, he charged his son Alcmæon to murder the betrayer as soon as he received information of his death. Amphiaraus perished in the expedition; and his death was no sooner known than his last injunctions were obeyed, and Eriphyle was murdered by the hands of her son.

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[1] Henry's History of Great Britain, vol. i. p. 344.

[2] Montfaucon Palæographia Græca, p. 42.

[3] Huetius de Interpretatione, p. 154.

ERIS, the goddess of discord among the Greeks. She is the same as the *Discordia* of the Latins.

ERISICHTHON, in fabulous history, a Thessalian, son of Triops, who derided Ceres and cut down her groves. This impiety irritated the goddess, who afflicted him with continual hunger; in consequence of which he squandered all his possessions in order to gratify the cravings of his appetite, and at last devoured his own limbs for want of food. Some say that his daughter had the power of transforming herself into whatever animal she pleased, and that she made use of this artifice in order to maintain her father, who had sold her, after which she assumed another shape, and again became his property.

ERLANGEN, a city of the circle of the Rezat, in the kingdom of Bavaria. It stands on the river Wernitz, is surrounded with ancient walls and towers, and though antique, is well built, and has broad streets. It contains a royal palace, three Lutheran churches, two Reformed, and one Catholic, and 815 houses, with 9800 inhabitants. It is the seat of the only exclusively Protestant university in the kingdom, which has twenty-six professors, and about 200 students, with a library of 80,000 volumes, a botanic garden, and several museums, with an anatomical theatre, and a chemical laboratory. There are numerous manufactures carried on, of cottons, hats, hosiery, gloves, paper, cutlery, &c. Long. 9. 1. 5. E. Lat. 49. 35. 36. N.

ERLAU, or EGER, a city of Hungary, in the circle of the Hither Theiss. It contains an Episcopal palace and cathedral, a university with ten professors, an observatory and public library, three cloisters for monks and one for the Brethren of Mercy, with 1710 houses, and 16,112 inhabitants. There are here manufactures of linen and woollen goods, and much good wine is also made. Long. 20. 17. 51. E. Lat. 47. 53. 36. N.

ERMIN, in *Heraldry*, denotes a white field or fur, powdered or interspersed with black spots, called *powdering*.

ERMIN, an order of knights instituted in 1450, by Francis I. duke of Bretagne, and which formerly subsisted in France. The collar of this order was of gold, composed of ears of corn in saltier, at the end of which hung the ermine, with the inscription *à ma vie*. But the order expired when the dukedom of Bretagne was annexed to the crown of France.

ERMINES, in *Heraldry*, the reverse of ermine, that is, white spots on a black field.

ERMINOIS, in *Heraldry*, signifies the field or, and the spots black.

ERNATIA, a town of Asiatic Turkey, in Natolia, situated on the Gulf of Satalia, sixteen miles north-west of Satalia. Long. 30. 24. E. Lat. 36. 50. N.

ERNESTI, JOHN AUGUSTUS, one of the most illustrious philologers and theologians of the last century. He was born on the 4th August 1707, at Tennstadt, of which place his father, likewise a distinguished theologian, was pastor, and superintendent of the electoral dioceses of Thuringia, Salz, and Sangerhusen. After having received his first instruction in the learned languages, under the domestic discipline of his father, and in the gymnasium of his native town, he was sent at the age of sixteen to the celebrated Saxon cloister school of Pforta. Here he continued four years. At the age of twenty he entered the university of Wittemberg, where he studied eloquence and ancient literature under the celebrated Berger, theology under Wernsdorf, and the Wolfian philosophy under Schlosser. From Wittemberg he passed to the university of Leipsig, where he applied himself to the mathematical sciences under Hausen, following the courses of Boerner and Deyling on theology, and the lectures of Gottsched on German eloquence. In 1730 he was made master in the faculty of philosophy. In the following year he accepted the office of conrector in the Thoman school of Leipsig, of which J. M. Gesner was then rector; and on Gesner's vocation, as professor of eloquence, to Göttingen, he succeeded him as rector. In this situation, by his erudition, diligence, and the elegance of his methods, he surpassed all his contemporaries, and created an epoch in Germany for the study of the ancient authors. From this office, in opposition to the present custom, which precludes a translation into the universities to the masters of the subordinate schools, he was, in 1742, named as extraordinary professor of ancient literature in the university of Leipsig, and in 1756 promoted to the ordinary professorship of eloquence. In both these chairs he knew how to combine more intellect, philosophy, and taste, than had been done by any of his predecessors. His reputation as a scholar, and his rational treatment of the biblical exegesis, paved the way for his entrance into the theological faculty. Through the elegance of his learning, and his manner of discussion, he co-operated with Baumgarten of Halle in disengaging dogmatic theology from the scholastic and mystical excrescences with which it was then deformed; and thereby contributed greatly to the new revolution in theology, although he himself never deviated from the ancient system. In these deserving labours, and with unbroken health, he attained an honourable old age; and died, after a short illness, in his seventy-sixth year, on 11th September 1781.

Whether Ernesti be considered as a philologer or theologian, it is perhaps as much from the impulsion which he gave to sacred and profane criticism in Germany, as from the intrinsic excellence of his own works in either department, that he must derive his reputation. With Gesner, he instituted a new school in ancient literature; and, after Crocus, Melanchthon, and Camerarius, has been perhaps the greatest reformer and promoter of classical learning in Germany. With Semler he partially co-operated in the great revolution of Lutheran theology; though he is guiltless of all participation in the deductions which many of those who profess themselves his disciples have drawn from the principles which he established.

An enthusiastic and enlightened study of the ancient Greek and Roman authors is the well-merited boast of the present German literature. This commenced, in its existing form, towards the middle of the last century. Not that Germany, before that period, had neglected ancient literature, or could not enumerate her proportion among the great names of classical erudition. No nation, in fact, had produced so many, or more illustrious, scholars immediately after the Reformation; but for a long time polite literature had become deformed, if not neglected, in proportion as religious wars and polemical theology had exhausted and engrossed her governments and universities. The German scholars were chiefly theologians, and theologians who had studied every thing in reference to their peculiar profession. Add to this, that the most disgusting and inefficient methods had been introduced, whereby the spirit of the instruction was at utter variance with the object of the study. Accordingly, during the whole of the seventeenth and the first half of the eighteenth century, Germany was far excelled by Holland in the number and excellence of her philologers; and it was not until the appearance of Gesner and Ernesti, with their somewhat earlier contemporaries, Cortius, Daniel Longolius, and Michael Heusinger, that she could oppose above one or two rivals to the great critics of the Dutch schools. Gesner and Ernesti, however, through the influence of their lectures at the greater universities of Göttingen and Leipsig, through the wider extent of their labours in philology, and still more through the greater excellence of their methods, are alone entitled to be held the founders of the new German school of ancient literature. Both excelled their philological countrymen in taste, in the elegance of their Latin style, in a philosophical spirit, and in a wider acquaintance with the subsidiary branches of erudition. Both made an advantageous use of their critical knowledge of the languages; both looked at once to the words and to the subject of the ancient writers, established and applied the rules of a legitimate interpretation, and carefully analysed the meaning as well as the form of the expression. Both contributed effectually to expel the old absurd and disgusting methods of instruction from the schools and universities, and to introduce an improved and more effectual system. To the epoch which they formed, many circumstances indeed contributed:—their acquaintance with the Dutch criticism; the universal enthusiasm of the Germans for establishing a national literature, and for becoming at the same time reformers in the departments of ancient learning; and withal the spirit of philosophy which at that period in Germany began more and more to blend itself with every part of science and literature. It is also true that their editions do not possess the complement of erudition and criticism which distinguish those of many of their contemporaries; their commentaries have the precision, but how inferior are they in certainty, copiousness, and depth of illustration, to those of the philologers of Holland? In their editions of the Latin classics, they returned back to the somewhat inconvenient method of Cellarius, collecting their principal illustrations into an *Index Rerum et Verborum*, as is done by Gesner in his *Quintilian*, and by Ernesti in his *Cicero*; not, however, that they did not possess the means of illustrating their author with a rich critical and philological commentary, of which the former has given ample proof in his editions of the *Scriptores de Re Rustica*, and in his *Claudian*, and the latter in his two most valuable labours, his *Suetonius* and *Tacitus*. Both, but especially Ernesti, have detected grammatical niceties in the Latin tongue, which had escaped all preceding critics; such, among others, are the use of the subjunctive mood after the pronoun *qui*, and the legitimate consecution of the tenses. His canons are, however, not without exceptions. As an editor of the Greek classics, Ernesti deserves hardly to be named beside his Dutch contemporaries, Hemsterhuis, Valkenaer, Ruhnken, or his colleague and enemy the learned and unfortunate Reiske. How insignificant are his own labours in his editions of Homer and Callimachus? In regard to the higher criticism, it was not even attempted by Ernesti. But to him and to Gesner the peculiar praise is owing of having formed, partly by their discipline, and partly by their example, philologers greater than themselves; and to them is due the honour of having so strongly excited in Germany that enthusiasm for ancient learning, which has now, unfortunately, no parallel in the other countries of Europe.

As a theologian, Ernesti is far less conspicuous than as a scholar, and his influence not so marked either on his contemporaries or on his successors. Before the middle of the eighteenth century, the Spenerian pietism had been almost banished from the Lutheran theology; and the professors of that faculty in the Protestant universities of Germany no longer excluded philosophy from all interference in the doctrine of Christian belief. It had then been boldly proclaimed and maintained with pre-eminent ability by Semler, that Luther had commenced and not finished the Reformation of religion; but that this Reformation must still proceed, and that religion, like other branches of knowledge. must become purer and more perfect in proportion to the increase of knowledge and the development of the human mind. At this date, accordingly, the theologians of Germany had begun to disregard the nonconformity of their doctrines with the formula of the Lutheran church; and after this period few were at all apprehensive of openly controverting its tenets when at variance with the results of their own speculations. From the unrestrained freedom of thought in matters of religion which was now indulged, if not even encouraged, by the governments in their different universities, every one was at perfect liberty, without any derogation from his character as a clergyman or instructor, to maintain and promulgate what opinions in religion he chose; and it must be acknowledged that the theologians have made, and are still making, every use and abuse of this license, and have arrived at every conclusion that piety and learning, as well as presumption, folly, and irreligion can suggest. It was at the commencement of this important era that Ernesti flourished as a theologian.

Of the three sciences subsidiary to theology, philosophy, history, and grammatical exegesis, the first had been imperfectly applied, and without any interesting result, by Baumgarten, a scholar of Wolf; but the second, the historical interpretation, had, in the hands of Semler, been productive of conclusions subversive of much that had been hitherto held orthodox and even sacred. In the grammatical interpretation of the New Testament some imperfect progress had been made by Bengel; but the new epoch in the biblical exegesis commences with John David Michaelis for the Old, and with Ernesti for the New Testament. It is, indeed, chiefly in *hermeneutic* that Ernesti has any claim to the character of a great theologian. But here his merits are distinguished, and, at the period when his *Institutio Interpretis N. T.* was published, almost peculiar to himself. He applied himself to the interpretation of the sacred Scriptures, after a long and familiar acquaintance with the Greek and Roman writers, and when formed in his mind and taste by a constant study of these patterns. His interpretation of the New Testament bears the character of both these circumstances. It is not only the matter, but at the same time the manner in which it is conveyed,—it is the selection of subjects, with the precision, the pregnant brevity, the elegance and simplicity, in which they are expressed,—that confers on this little book so high and so singular a value. We find in it the principles of a general interpretation, and this without the assistance of any particular philosophy, not even of the Wolfian, to which Ernesti was attached; but consisting of observations and rules, which, though already enunciated, and applied in the criticism of the profane writers, had never rigorously been employed in the biblical exegesis. He admits in the sacred writings only *one acceptation*, and that the *grammatical*, convertible into and the same with the *logical* and *historical*. The Scriptures, therefore, having this in common with all other writings, it follows that they can only be explained like mere human compositions; that the rules of interpretation are the same in both; and that only through some peculiar constitution of speech and writing could any possible distinction between these subsist. He therefore justly censures the opinion of those who, in the illustration of the Scriptures, refer every thing to the illumination of the Holy Spirit; as well as that of others who, in contempt of all knowledge of the languages, would explain words by things, and thus introduce into the holy writings their peculiar glosses and opinions. The *analogy of faith*, as a rule of interpretation, he greatly limits, and teaches that it can never alone afford the explanation of words, but only determine the choice among their possible significations, and must always stand in need of philology as an assistant. The spirit of Ernesti's interpretation gives no countenance, however, to the results which many of his followers have deduced from the grammatical and historical exegeses. Every principle of his interpretation rests on the assumed inspiration of the holy books; and there is not perhaps a better antidote to the poisonous tenets of many of those who profess to be of his school, than the diligent study of his *Interpres*, and the relative *Acroases* of Morus. In the higher criticism of the sacred books Ernesti did nothing. In dogmatic he always expressed great contempt of strict systematic theology; and though he lectured for many years on the Aphorisms of Neumann, it was rather in refutation than in support of his text-book.

Among his works the following are the more important:

I. In profane literature:

Initia Doctrinæ Solidioris, 1736, 8vo; many subsequent editions. A work not only valuable by reason of the real excellence of the matter, but more particularly deserving an attentive study, on account of the purity of the Latin, in discussing subjects of philosophy known only to the moderns.

Initia Rhetorica, 1730.

Xenophontis Memorabilia Socratis, cum notis, 1737; often reprinted.

Ciceronis Opera cum clave, 1737; 2d edit. Halæ, 1757; 3d edit. ibid. 1776, 8vo, 6 vols.

Suetonius cum Animadversionibus, 1748; 2d edit. 1775-8.

Taciti Opera cum notis J. Lipsii, Jo. Fr. Gronovii et suis, 1752; 2d edit. 1772; 8vo. Another edition, with many additions and improvements, has been procured by Oberlin.

Aristophanis Nubes cum Scholiis Antiquis et præfatione, 1754, 8vo.

Corradi Quæstura cum præfatione, 1754, 8vo. See Wyttenbach in his *Vita Ruhnkenii.*

Hederici Lexicon Græcum, multis Vocabulorum millibus Auctum, 1754–67, 8vo.

Homeri Opera Omnia, ex Recensione, et cum Notis Sam. Clarkii, accessit Varietas Lectionum MS. Lips. et Edit. Vet. cura J. A. E. qui et suas Notas adspersit, 1759–64, 5 vols. 8vo.

Callimachi Hymni et Epigrammata, cum Notis Var. Latine vertit atque Notis adjecit. Lugd. Bat. 1761, 8vo, 2 vols.

Polybius cum Notis Var. Præfationem et Glossarium Polybianum adjecit. Viennæ et Lips. 1764, 3 vols. 8vo.

Archæologia Litteraria, 1768. A new and improved edition by Martini.

Horatius Tursellinus de Particulis, 1769, 8vo.

Fabricii Bibliotheca Latina nunc melius delecta, rectius digesta et aucta, vol. i. and ii. 1773; vol. iii. 1774, 8vo, unfinished.

II. In sacred literature:

Antimuratorius sive Confutatio Disputationis Muratorianæ de rebus Liturgicis, 1755–58.

Neue Theologische Bibliothek, vol. i. to x. 1760–69, 8vo.

Institutio Interpretis Nov. Test. 1761, reprinted in the same year at Leyden; 2d edit. 1765; 3d edit. 1775; 8vo.

Neueste Theologische Bibliothek, vol. i. to x. 1771–75, 8vo.

Besides these, he published above a hundred smaller works in the form of prefaces, academical dissertations, programmata, memoriæ, elogia, epistles, orations, translations, &c. Many of these have been collected in the three following publications:—*Opuscula Oratoria*, Lugd. Bat. 1762; 2d edit. 1767; 8vo. *Opuscula Philologica et Critica*, Lugd. Bat. 1764; 2d edit. 1776; 8vo. *Opuscula Theologica*, Lips. 1773, 8vo.

EROS (from ερως, *love*), in *Mythology*, one of two chiefs of the cupids, being the cause of love.

EROSION, among physicians, denotes nearly the same thing with corrosion, only in a stronger degree.

EROTIA, a festival instituted in honour of Eros, the god of love. It was celebrated by the Thespians every fifth year, with sports and games, when musicians and others contended. If any quarrels or seditions had arisen amongst the people, it was then usual to offer sacrifices and prayers to the god that he would totally remove them.

EROTIC (derived from ερως, *love*, whence ερωτικος) is applied to any thing which has a relation to the passion of love.

EROUAD, or Erroad, a town of Hindustan, in the province of Coimbetoor. It contained during the reign of Hyder about 3000 houses, but was reduced to one third in the reign of Tippoo; and during the invasion of General Meadows the town was destroyed. It is now fast recovering, and contains about 400 houses. It was taken by the British in 1768, and retaken the same year by Hyder. It was again taken by the British in 1790, and retaken by Tippoo; but it came into the final possession of the British, along with the province, in 1799. A canal has lately been cut in its vicinity, and is expected to be productive of much benefit to the inhabitants. Long. 77. 50. E. Lat. 11. 19. N.

ERPENIUS or d'Erpe, Thomas, a celebrated orientalist, born at Gorcum in Holland, on the 7th September 1584. Observing his aptitude for learning, his father sent him to Leyden at the early age of ten; and it was in that city that he commenced his studies. At the end of several months, however, he went to Middelburg, where he remained some time; but in about a year he returned to Leyden, where he had opportunities of indulging his tastes with greater facility. His progress was so rapid, that at a very tender age he was admitted into the university of that city, and in 1608 took the degree of master of arts. At the solicitation of Scaliger he learned the oriental languages whilst taking his course of theology, and even then gave promise of the distinction which he was destined to attain in that department of learning. After he had completed his studies he travelled in England, France, Italy, and Germany, forming connections with learned men, and availing himself of the information which they communicated. During his stay at Paris, he contracted a friendship with Casaubon, which lasted during his life, and also took lessons in Arabic from Joseph Barbatus, otherwise called Abu-dakni. At Venice he held conferences with both Jews and Mahommedans, and profited by his residence in that city to perfect himself in the Turkish, Persic, and Ethiopic languages. After a long absence, Erpenius returned into his own country in 1612, rich in the learning which he had acquired during his travels, as well as beloved and esteemed by all the learned whom he had visited. His acquirements being already known and appreciated, he was, on the 10th February 1613, appointed professor of Arabic and other oriental languages, Hebrew excepted, in the university of Leyden. From this period he devoted himself solely to the teaching of these languages, to facilitate the study of them, and to extend a knowledge of them by means of his works. Animated by the example of Savary de Brèves, who had established at his own charge an Arabic press at Paris, he caused new Arabic characters to be cut at a great expense, and erected a press in his own house. In 1619 the curators of the university of Leyden instituted a second chair of Hebrew in his favour. In 1620, the States of Holland sent him to France, to endeavour, by the promise of a chair of theology, to induce Pierre Dumoulin or André Rivet to settle in that country; but this first journey proved unsuccessful, and was followed, the year after, by a second, which

Erpenius.

had the desired effect, as Rivet closed with the terms offered him, and passed into Holland. Some time after the return of Erpenius, the States appointed him their interpreter; an office which imposed upon him the duty of translating and replying to the different letters of the Moslemin princes of Asia and Africa. The king or emperor of Morocco, it is said, took great pleasure in reading his Arabic letters, and in pointing out the elegance and purity with which they were written. But be this as it may, the reputation of Erpenius had now spread throughout all Europe; and several princes, the kings of England and Spain, and the archbishop of Seville, made him the most flattering offers; but he constantly refused to leave his native country, and died of a contagious distemper on the 13th of November 1624, at the early age of forty. Erpenius left several works, which are doubtless not perfect; but if we consider that he lived in an age when pursuits like his were exceedingly rare, if not wholly new, that he had little or no assistance of any kind, and that in fact he formed himself; and if we judge him, not according to the present state of oriental literature, but by what he actually achieved under every disadvantage, we must conclude that, in the immensity and difficulty of his labours, he probably surpassed all the orientalists who have followed him; and that if his career had not been cut short by a premature death, he would have greatly enlarged the boundaries of that literature of which his name will always remain one of the greatest ornaments. The following is a list of his works:—1. *Oratio de Lingua Arabica*, Leyden, 1613, in 4to; 2. *Annotationes in Lexic. Arab. Fr. Raphelengii*, ibid. 1613, in 4to; 3. *Grammatica Arabica, quinque libris methodice explicata*,[1] ibid. 1613, in 4to; 4. *Proverbiorum Arabicorum centuriæ duæ, ab anonymo quodam Arabe collectæ*, ibid. 1614 and 1623, in 8vo; 5. *Locmani sapientis Fabulæ et selecta quædam Arabum Adagia, cum interpretatione Latina et notis*, ibid. 1615, in 8vo; 6. *Pauli Apost. ad Romanos, Arabice*, ibid. 1615, in 4to; 7. *Novum D. N. J. C. Testamentum, Arabice*, ibid. 1616, in 4to; 8. *Pentateuchus Mosis, Arabice*, ibid. 1622; 9. *Historia Josephi Patriarchæ ex Alcorano, cum triplici versione Latina et scholiis Th. Erpenii, cujus præmittitur Alphabetum Arabicum*, ibid. 1617, in 4to; 10. *Grammatica Arabica dicta Giarumia et libellus centum regentium cum versione Latina et Commentariis*, ibid. 1617, in 4to; 11. *Canones de litterarum Alif, Waw, et Yé apud Arabes naturo et permutatione*, ibid. 1618, in 4to; 12. *Rudimenta Linguæ Arabicæ; accedunt Praxis Grammatica et consilium de studio Arabico feliciter instituendo*, ibid. 1620, in 8vo; 13. *Orationes tres de linguarum Ebreæ et Arabicæ dignitate*, ibid. 1621, in 12mo; 14. *Historia Saracenica*, ibid. 1625, in fol.; 15. *Grammatica Ebræa Generalis*, ibid. 1621, in 8vo; 16. *Grammatica Syra et Chaldæa*, ibid. 1628; 17. *Psalmi Davidis, Lyriace*, ibid. 1628; 18. *Arcanum punctuationis revelatum et Oratio de nomine Tetragrammato; 19. Versio et Notæ ad Arabicam Paraphrasin in Evang. S. Joannis*, Rostock, 1626; 20. *De Perigrinatione Gallicâ utiliter instituenda tractatus*, ibid. 1631, in 12mo; 21. *Præcepta de Lingua Græcorum communi*, Leyden, 1662. Erpenius had projected several other works, particularly an edition of the Koran with notes, and an oriental library; and in the prefaces of his grammars he also speaks of a *Thesaurus Grammaticus*, which, however, has not seen the light. For further information respecting this celebrated orientalist, the learned reader may consult Vossius, *Oratio in obit. Th. Erpenii*, Leyden, 1625, in 4to, and Scriverius, *Manes Erpeniani, quibus accedunt Epicedia variorum*, ibid. 1625.

ERPETOLOGY. See Reptilia.

ERRATIC, in general, something that wanders, or is not regular. Hence the planets are called *erratic stars.*

ERROMANGO, an island in the South Pacific Ocean, one of the New Hebrides, about ninety miles in circumference. The inhabitants are black. Long. 169. 20. E. Lat. 13. 50. S.

ERROOR, a fortified town of the south of India, in the province of Mysore. The Hoggree river runs close past the fortifications, to which there is a flight of steps from the water's edge, built by some pious Mahommedan. It was plundered by the Mahrattas in 1790. Long. 76. 39. E. Lat. 13. 48. N.

ERROR, in *Philosophy*, a mistake of the judgment, or giving assent to that which is not true. Mr Locke reduces the causes of error into these four: first, want of proofs; secondly, want of ability to use them; thirdly, want of will to use them; and, fourthly, wrong measures of probability.

ERSKINE, Thomas, Lord Erskine, a distinguished lawyer and statesman, was the third and youngest son of David Henry Erskine, tenth earl of Buchan, in Scotland. He was born in Scotland, and received his education partly at the high school of Edinburgh, and partly at the university of St Andrews. From the contracted resources of his family, it was necessary for him to fix upon a profession. He chose the navy, and having embarked at Leith as a midshipman, he quitted his native country, which he did not revisit until a few years before his death. In the navy he experienced no advancement, and, after four years' service, he entered the army in the year 1768. In 1770 he married, and shortly after this event he accompanied his regiment to Minorca, where he remained during three years. It is not certain whether his abilities as an officer ever rendered him conspicuous, but the versatility of his talents, and the acuteness of his intellect, thus early brought him a high reputation. By the earnest persuasion of his mother, who, it would appear, was a woman of more than ordinary penetration, he was induced to quit the army after six years of military probation. The legal profession was the one which appeared best adapted for the character of his mind; and in 1777 he entered as a fellow commoner at Trinity College, Cambridge, for the purpose of obtaining a degree, which he was entitled to as the son of a nobleman, and thereby of shortening his passage to the bar. At the same time he entered himself as a student at Lincoln's Inn. In 1778 he was called to the bar, where his success was immediate and remarkable. In a case of libel, in which he advocated the cause of Captain Baillie, the defendant, he displayed so much eloquence and talent, that the legal world was astonished, and thirty retainers were put into his hand by attornies before he left the court. A few months after this event he was honoured by being chosen to appear at the bar of the House of Commons, as counsel against a bill of Lord North's to restore to the universities the monopoly in almanacks. The bill was lost by a large majority, and the speech which Mr Erskine made upon the occasion so established his reputation for forensic skill, that he was from this period engaged, either on one side or another, in every case of importance, during a practice of twenty-five years. To this period also belongs his famous speech in defence of Lord George Gordon, which was a case of what is called constructive treason. Erskine procured a clear acquittal of his client, which was for the time a deathblow to the tremendous doctrine of constructive treason. In May 1783 he received a silk gown, and the same year was elected member of parliament for Portsmouth, for which borough he was on every election re-chosen, until his advancement to the peerage rendered that honour unnecessary. When the eldest son of George III. obtained his establishment as Prince of Wales, he chose Mr Erskine as his attorney-general. But there is nothing in the life of this eminent man which reflects so much honour on his memory as his exertions in defence of the privileges of juries. The rights of those *pro tempore* judges he strenuously maintained upon all occasions, particularly in the celebrated trial of the Dean of St Asaph, for libel, when Justice Buller refused to receive the verdict of *guilty of publishing only*, as returned by the jury. In 1789 another opportunity was afforded him to display his peculiar powers. This was the defence of a Mr Stockdale, a bookseller, who was tried on an information filed by the attorney-general, for publishing what was charged as a libellous pamphlet in favour of Mr Hastings. The situation of the latter, whose celebrated but protracted trial was then dragging its slow length along, gave Erskine admirable scope for that animated appeal to the feelings, by which his speeches are so much distinguished. It is one of his finest orations; and, whether we regard the wonderful skill with which the argument is conducted, the soundness of the principles laid down, and their happy application to the case, the vividness of fancy with which these are illustrated, and the touching language in which they are conveyed, it is justly to be regarded as a consummate specimen of the art of addressing a jury. This masterly defence procured a clear acquittal for Stockdale, although the fact of publication was admitted. Not long afterwards he advocated the cause of Mr Perry, editor of a London newspaper, who was also charged with publishing what the jealous loyalty of those times construed into a libel; and his speech produced a similar result. But the most arduous effort of his professional life arose out of the part cast upon him, in conjunction with Mr, afterwards Sir Vicary, Gibbs, in the trials of Hardy, Tooke, and others, for high treason in 1794. These trials lasted several weeks, and the ability displayed by Mr Erskine upon this memorable occasion was acknowledged and admired by men of all parties. His speech in defence of Mr Frost, which, however, preceded those above mentioned, is another of those almost miraculous exertions, which, in that momentous crisis, Mr Erskine made for the liberties of his country. Frost was accused of uttering seditious words, which, however, turned out to have been spoken at random in a coffee-house whilst the accused was in a state bordering on intoxication. In the violence of that day, the exertions of Erskine failed of their accustomed effect, and Frost was found guilty. But the impression of his defence was not lost; and it deterred the government from risking its credit on such precarious speculations, until, as we have noticed, the charges of high treason were brought forward, when the whole force of the bar was marshalled against the prisoners, and every effort used to beat down and paralyse their undaunted defender. But his spirit rose superior to every difficulty, and then it was that his consummate talents shone forth in their native lustre. His indefatigable patience, his sleepless watchfulness, his unceasing activity of body and mind, his untameable spirit, his quickness and subtilty of intellect, together with a herculean strength of constitution, counterbalanced the host to which he was opposed. Such were the gigantic powers of the man; the wonderful eloquence of the forensic orator is only to be spoken of as second to these.

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[1] This grammar, says Schnurrer, which may be regarded as the first composed in Europe, has not only been often reprinted, but it has so made the law, or, in other words, served as a model, that several professors, particularly in Germany, who have published Arabic grammars under their own names, have followed the footsteps of Erpenius, and have never ventured to deviate from the course marked out by their guide.

Mr Erskine was a warm partizan of Mr Fox, and the liberal party of that time. He strenuously opposed the war with France, and published a pamphlet against it, entitled *A View of the Causes and Consequences of the War with France*, which had an immense sale. In 1802 the Prince of Wales not only restored him to his office of attorney-general, of which he had been deprived, but made him keeper of the seals for the duchy of Cornwall. On the death of Pitt in 1806, when Lord Grenville received orders to form a new administration, Mr Erskine was created a peer, by the title of Lord Erskine, of Restormel Castle in Cornwall, and elevated to the dignity of lord high chancellor of Great Britain. His previous experience in the courts of common law scarcely fitted him for the judicial functions of this dignified office; but there seems little doubt that his natural quickness of intellect would have triumphed over every difficulty, had not a dissolution of the administration of which he formed part been accelerated by the obstinacy of the king on the subject of the Catholic claims. His public career may be said to have terminated with this event, and the remainder of his life was undistinguished by any great exertion, whilst it was unhappily embittered by pecuniary difficulties, which were enhanced, it is said, by an unfortunate second marriage. His mind, however, retained its native elasticity, and in his retirement he employed himself in editing several of the state trials. He also wrote the preface to Fox's speeches, a political romance entitled *Armata*, and several pamphlets in support of the Greek cause. Whilst accompanying one of his sons by sea to Edinburgh, he was seized with an inflammation of the chest, which compelled him to land at Scarborough. He reached Scotland by easy stages, but expired on the 17th of November 1823, at the seat of his brother, situated a few miles from Edinburgh. The peculiar character of Lord Erskine's eloquence has already in some measure been described. In his capacity of advocate he possessed the power of summoning upon the instant all the resources of his mind, and bringing them to bear upon the subject before the court with extraordinary effect. In this respect his speeches bear a resemblance to those of Mr Pitt, whilst they far surpass them in impassioned fervour, in brilliancy of imagination, in copiousness of imagery, and in that quality of mind expressed by the emphatic word genius. His dexterity was likewise unrivalled at the bar; and these qualifications, united with a courage which nothing could daunt, and a firmness which was never overcome, rendered him almost irresistible on the defensive side of political persecution. Amidst all the struggles of the constitution in parliament, in council, and in the field, during that momentous period of our national history, there was no man to whose individual exertions it owed so much as to those of this celebrated advocate. In stemming the tide of state prosecutions, this single patriot may be said to have saved his country from the horrors of a general proscription. As a senatorial orator his claims were but secondary; and as a political writer he is not entitled to much distinction. His sphere was the bar, and there, as the advocate of injured worth or persecuted political honesty, he never had a rival before, and he has left no equal behind him.

By his first wife, who died in 1805, Lord Erskine had three sons and five daughters. His speeches have been frequently printed; the last edition is in 5 vols. 8vo. (R. R. R.)

ERYMANTHUS, a mountain, river, and town of Arcadia, where Hercules killed a prodigious boar, the carcass of which he carried on his shoulders to Eurystheus, who was so terrified at the sight that he hid himself in a brazen vessel.

ERYSIPELAS, in *Medicine*, an eruption of a red or fiery kind, from which no part of the body is exempted, though it chiefly attacks the face.

Erythræ || Erzerum.

ERYTHRÆ, in *Ancient Geography*, a port of Ætolia, on the Bay of Corinth. The Erythræans considered the Sibyl Herophile as their countrywoman, and she was thence surnamed *Erythræa*. Erythræ was famous for an ancient temple of Hercules.

ERYTHRÆUM MARE was used, at the time when the Greeks possessed little accurate information respecting India, to designate the whole ocean to the south of Asia, which washed the coasts of Arabia, Persia, and Western India. The boundary of the Erythræan Sea was determined by a line drawn from the outlet of the Red Sea or Arabian Gulf, to the southern extremity of India. Its name was probably derived from that of some prince; for we can scarcely ascribe it to any supposed redness of colour, which the word in the Greek language means. In course of time, however, it was restricted to the sea south of Arabia; and in this signification it was understood by Strabo (xvi. 765, 766). Herodotus (i. 180), indeed, seems to have known nothing of the Persian Gulf, but to have considered the river Euphrates as falling at once into the *Mare Erythræum*.

ERYX, a son of Butes and Venus, who, relying upon his strength, challenged all strangers to fight him with the cestus. After many had yielded to his superior dexterity, Hercules accepted his challenge, and Eryx was killed in the combat, and buried on the mountain, where he had built a temple to Venus (Virg. *Æn.* v. 402). A mountain of Sicily near Drepanum also received its name from Eryx, who was buried there. This mountain was so steep that the houses which were built upon it seemed every moment ready to tumble down; but Dædalus enlarged the top, which he enclosed with a strong wall, and also consecrated to Venus Erycina a golden heifer, which so much resembled life that it seemed to exceed the power of art.

ERZERUM, the capital of one of the most considerable pashaliks in Armenia, of the same name, which is ruled by a pasha of three tails. It is surrounded on all sides by mountains, the highest peaks of which are covered with snow; and it lies in a valley beneath. The streets are in general paved, and the houses are built of stone, with rafters of wood and terraces. On the tops of these the grass grows, and they afford pasture for sheep; so that when seen from a distance they appear to form part of the plain in front of the town, which is about twenty miles in circumference, and is embellished with upwards of sixty villages. Towards the south the town is protected by a citadel, mounting twenty pieces of cannon of different calibres. It is surrounded by a double wall of stone, and has four gates covered with plates of iron. On the eastern face this work assumes a modern appearance, having regular embrasures; but, from its want of solidity, it is equally defenceless with any other part of the castle. In the eastern part of the city is an old brick tower, the loftiest building in the place, with a clock on the summit which strikes the hours with tolerable regularity. It contains forty-five mosques and two churches. Two of the most ancient of the mosques are beautifully ornamented with bricks and coloured tiles, which lofty domes, together with the glittering minarets of others, give a delusive appearance of splendour to the city when seen from a little distance, which totally vanishes on a nearer view. There are, besides, a Greek church and a large Arminian chapel; and at some distance from the city are three celebrated monasteries. The bazars are extensive, and well supplied with provisions, excepting fruit, which is brought by the Georgians from the province of Akiska, a distance of three or four days' journey. It has manufactures of considerable importance, and carries on an extensive trade in copper, and in articles from Persia, and from the countries to the north-west of Hindustan. In winter the cold is intense; it commences in August, and snow lies on the ground from October to March. The air is however pure, the water good, and the inhabitants in general healthy. The town was visited by the plague in 1807, which carried off a great number of the inhabitants. The population amounts, according to some, to 100,000 or 130,000, and consists of Turks, Greeks, Persians, and Armenians. Sir R. K. Porter's estimate is only 6000 Christians and 50,000 Mahommedans. It is two hundred and fifty miles north-north-east of Aleppo. Long. 40. 57. E. Lat. 39. 57. N.

ESARHADDON, the son of Sennacherib, and his successor in the kingdom of Assyria. He is said to have reigned twenty-nine years at Nineveh, from the year 3294 to 3322; besides which he reigned thirteen years at Babylon, making in all forty-two years. He died in the year of the world 3336, and was succeeded by Saosduchinus. Esarhaddon Sir Isaac Newton considers as the same with the Sardanapalus, who, according to Clectarchus, died of old age, after the revolt of Syria; the name *Sardanapalus* being derived from *Asserhadon Pul.*

ESCALADE, or SCALADE, an attack of a place without proceeding in form, or carrying forward regular approaches. It is usually made by means of ladders, which are employed for enabling the assailants to descend into the ditch, where such exists, and then to scale the rampart.

ESCHEAT, in *Law*, signifies any land or tenement that casually falls to a lord within the manor.

ESCHENBACH, a bailiwick of the circle of the Upper Maine, in the kingdom of Bavaria, extending 264 square miles. It contains two cities, three towns, 166 villages, and 2480 houses, with 15,316 inhabitants. The chief town, of the same name, once fortified, containing 180 houses, and 1056 inhabitants, employed in making linen cloth.

ESCHERSHAUSEN, a town in the Weser district of the duchy of Brunswick, on the river Lenne, containing, with Wickersen, 146 houses, and 1046 inhabitants. It is the capital of a bailiwick, which has 2030 houses, and 15,890 inhabitants.

ESCHEVIN, or ECHEVIN (*Scabinus*), in the French and Dutch polity, a magistrate elected by the inhabitants of a city, to manage their common concerns, and promote the good order, convenience, and decoration of the city.

ESCHRAKITES, or ESRAKITES, a sect of philosophers amongst the Mahommedans, who adhere to the doctrines and opinions of Plato. The word is derived from the Arabic *schraka*, which in the fourth conjugation signifies to shine or glitter like the sun, so that *Eschrakite* seems to signify illuminated.

The *Eschrakites*, or Mahommedan Platonists, place their highest good and happiness in the contemplation of the Divine Majesty, despising the sensual imaginations in the Koran concerning paradise. They are careful in avoiding all vice; they preserve an equal and easy temper, love music, and divert themselves with composing little poems or spiritual songs.

ESCHWEGE, a city of the province of Lower Hesse, in the principality of Hesse Casel. It is situated on the river Werra, and contains four churches, 782 houses, and 4845 inhabitants, employed in making cloth and tanning leather. It has some navigation on the Werra. In the vicinity a considerable quantity of tobacco is cultivated.

ESCOBAR, a town of Andalusia, in Spain, in the province of Jaen. It is situated on the declivity of the mountains of the Sierra Morena, near the descent of the river Jandula, which runs into the Guadalquiver.

ESCUAGE, in our old customs, a kind of knight-service, called *service of the shield*, by which the tenant was bound to follow his lord to the wars on his own charge.

ESCULENT, an appellation given to plants or roots which may be eaten; as beets, carrots, artichokes, leeks, onions, parsnips, potatoes, radishes, and the like.

ESCURIAL, a monastery and royal palace in Spain. It is situated to the north of Madrid, in a country the surface of which is covered with rocks, and where there is little shelter from the winds, which makes this elevated place very cold in the winter months. It is dedicated to St Lawrence, on account of Philip the Second having gained the battle of St Quentin, in 1557, on the day sacred to the memory of that saint. It is whimsically built in the form of the gridiron, on which that saint is said to have been broiled alive.

The cross bars of the gridiron, forming ranges of buildings, between which are courts, are inhabited by monks and ecclesiastics, and the pile of building which represents the handle is the royal palace.

The square part of the building is six hundred and forty feet in length, and five hundred and eighty in breadth. The projection which forms the royal palace is four hundred and sixty feet in length. It is about sixty feet in height, and at each angle is a square tower two hundred feet high. It is one of the largest, and perhaps one of the most tasteless, buildings in Europe.

The church, in the centre of this uncouth mass of stone, is very large, rich, and of a species of architecture calculated to fill the mind with awe on entering it. The high altar is most profusely adorned with marbles, agates, and jaspers, and the gold and silver furniture are of the most costly kind. The cupola which covers this church is the most correct object in the whole of the vast pile. The Pantheon, a repository beneath this church, is the place of interment for the royal family, the bodies of whom are deposited in tombs of marble placed in niches, one above another. The richest part of this palace, however, was that which contained the valuable pictures to be seen in almost every part of it, and which altogether formed the best collection of the productions of the first masters that any place in Europe displayed. We speak of what it was; for the French, when in possession of the Escurial, robbed it of some of its best treasures, and it is not accurately known what portion has been left in the place. The best productions of Reubens, Titian, Spagnoletti, Raffaelle, Baroccio, Velasquez, Murillo, and others, adorned this place, and were little known except by the descriptive catalogue, as very few travellers have heretofore visited Spain with a view principally to the contemplation of the fine arts.

The most valuable treasures of the Escurial are, however, the immense collection of ancient manuscripts which is preserved in the library of that place. Thousands of volumes of the Arabian writers are buried, and their names scarcely known, which, if carefully examined, would throw much light on the history of science and the arts at that period when the mind of Europe, emerging from the darkness of the middle ages, first began to develope those higher qualities, the improvement of which was prodigiously accelerated by the invention of printing, and the impulse which the reformation gave to the minds of men in all parts of Europe. It would be doing injustice to the literary character of Spain not to state that the learned societies of Madrid have, as far as their limited powers would admit, examined, classed, and described these treasures. Some of them have been translated into Latin, others into Castillian, and more attention was being given to the subject than it had previously attracted, when the irruption of the French suspended every pursuit that was not directed towards the purposes of warlike defence.

There are some good statues, busts, and medallions in the Escurial. That of St Lawrence, the patron, is very excellent, and said to be an antique; but some of the best of the Spanish artists have averred that the head was from an ancient statue of Bacchus, and the body of more modern workmanship, but nearly approaching in execution to the original portion. These kinds of treasures are, however, less valued by the monks who show the place, than the autographs of several of the saints, which, as they affirm, are preserved here, and certainly exhibited with great veneration, and implicit faith in their genuineness.

As this place has been chiefly occupied by the royal family for the sake of the sports of the field, for which the surrounding country affords ample means in game of every description, it has been generally inhabited during the winter months, when, from its exposed situation, it is a most uncomfortable place of residence. To obviate some of the evils of the situation, a town has been built near the monastery; but, like all forced operations of the kind, it has never flourished, and is now rapidly declining. The centre of the monastery, by accurate observations, is in west longitude 3. 37. 35. from London, and in north latitude 40. 35. 50.

ESCUTCHEON, or SCUTCHEON, in *Heraldry*, is derived from the French *escusson*, which is a corruption of the Latin *scutum*, and signifies the shield on which coats of arms are represented or emblazoned. Most nations, even from the remotest antiquity, were wont to have their shields distinguished by certain marks painted on them; and to be able to display these on their shields was a token of honour, none being permitted to have such until they had performed some honourable action.

ESDRAS, a Jewish priest, and doctor of the law. Artaxerxes Longimanus sent him with rich presents for the adornment of the temple at Jerusalem, which was rebuilt under Zerubbabel; and the king also ordered the neighbouring governors to provide him with whatever might conduce to the pomp of the Jewish religion, as well as to the exemption of the priests from paying taxes. He is supposed to have been the collector of the canon of Scripture, and to have added by divine inspiration some things which happened after the deaths of the authors. It is conjectured that he wrote the Chronicles, besides those books which bear his name, the last two of which are exploded even by the church of Rome.

ESHER, a town of Surrey, in the hundred of Elmbridge, on the road to Portsmouth, seventeen miles from London. An ancient palace of the bishops of Winchester, but which has been celebrated as the residence of Wolsey, continues in a modernized form to be an object of attention, but especially its park, through which meanders the river Mole. The population in 1801 amounted to 846, in 1811 to 951, in 1821 to 1108, and in 1831 to 1215.

ESK, the name of several rivers both in England and Scotland, particularly of one which forms part of the boundary between the two kingdoms. It runs from north-east to south-west, and gives name to the district of Eskdale.

ESKI-HISSAR, a small town of Asiatic Turkey, in Natolia. It is supposed to stand on the site of the ancient Stratonica, which was founded by a colony of Macedonians. The neighbouring plain is fertile in tobacco, which is collected by the inhabitants, who hang it up in their cottages to dry. It is situated sixteen miles westward from Mogla.

ESNE, or ESNEH, a considerable town of Upper Egypt. "Esneh," says Denon (*Travels*, ii. 103), "is the ancient Latopolis. Some remains are still visible of its port or quay on the bank of the Nile, which has often been repaired, but, notwithstanding all that has been done for it, still remains in a very miserable condition. This town also contains the portico of a temple, which appears to me to be the most perfect monument of ancient architecture. It is situated near the bazar in the great square, and would make an incomparable ornament to this spot, if the inhabitants had any idea of its merit; but instead of this, they have deformed it by the most miserable ruined hovels, and have devoted it to the vilest purposes. The portico is very well preserved, and possesses great richness of sculpture. It is composed of eighteen columns with broad capitals: these columns are noble and elegant, though they now appear in the most disadvantageous light: the rubbish should be cleared to find if any part of the *cella* remains." See article EGYPT.

ESPALIERS, in *Gardening*. See HORTICULTURE.

ESPALION, an arrondissement of the department of the Aveiron, in France, extending over 639 square miles. It is divided into nine cantons and 101 communes, and contains 63,376 inhabitants. The capital is a city of the same name, situated on the river Lot, on which are some mills for spinning cotton, and establishments for curing various kinds of leather. It contains 2038 inhabitants.

ESPLANADE, in *Fortification*, is the sloping of the parapet of the covered-way towards the field, and the same as the glacis of the counterscarp; but it has become in a great measure antiquated in this sense, and is now only applied to the empty space between the glacis of a citadel and the first houses of the town.

ESPOUSALS, in *Law*, signify a contract or promise made between a man and a woman to marry each other; and in cases where marriages may be consummated, espousals take place previously. Marriage is termed an espousal *de præsenti*.

The espousals amongst the Jews were either by writing, or by a piece of silver given and received, or by cohabitation. Amongst the Greeks, after the parents and friends of the young people had finished their negotiation, the couple themselves pledged their faith to each other; the man swearing that he would be constant and true, the woman that she would marry him, and make him master of all she had. They then ratified their agreement by a kiss and by joining right hands.

Amongst the Romans the espousals consisted in an engagement of friends on both sides, whether absent or present, in public or without witnesses. But the common way was by means of writings drawn up by common consent, and sealed by both parties; and besides this, the man sent a ring to the woman, consisting of iron, and without a stone.

ESQUIMAUX, a people of North America, inhabiting the vast tract of land known by the name of *Labrador*. They differ very considerably, both in aspect and manners, from the other American nations, and agree in most respects with the inhabitants of West Greenland.

ESQUIRE (from the French *escu*, and the Latin *scutum*, in Greek *σκυτος*, which signifies a hide, of which shields were anciently made, and with which they were afterwards covered) was originally he who, attending a knight in time of war, carried his shield; from which circumstance he was called *escuier* in French, and *scutifer* or *armiger* in Latin.

It is a matter somewhat unsettled, says Blackstone (b. i. ch. 12), what now constitutes this distinction, or who is a real esquire; for it is not an estate, however large, that confers this rank upon its owner. Camden, he adds, distinguishes them the most accurately, and he reckons four sorts of esquires: 1. The eldest sons of knights, and their oldest sons, in perpetual succession; 2. The eldest sons of younger sons of peers, and their eldest sons, in like succession; 3. Esquires created by the king's letters patent, and their eldest sons; 4. Esquires by virtue of their office, as justices of the peace, and others bearing any office of trust under the crown.

ESSAY, a trial or experiment for proving the quality of any thing; or an attempt to ascertain whether or not any invention will succeed.

ESSAY, in *Literature*, a peculiar kind of composition, the character of which is freedom, ease, and natural simplicity, without being confined to strict order and method, or worked up and finished like a formal system.

ESSAYING, or ASSAYING. See ASSAYING.

ESSEDARII, a sort of gladiators, mentioned by Seneca, Suetonius, and Cicero, who on some occasions engaged one another from chariots called *esseda*. The *essedum* was a sort of heavy chariot from which the Gauls and Britons engaged the Romans. See GLADIATOR.

ESSEN, a city of the Prussian province of Cleeve-Juliers, the capital of a circle of the same name. It is situated on the river Berne, is surrounded with walls, and contains two Catholic, a Lutheran, and a Reformed church, with 799 houses, and 5100 inhabitants, employed in making ironmongery articles, especially coffee-mills and cards for dressing cloths. Near to it are some very valuable coal-mines. Long. 6. 56. 1. E. Lat. 51. 27. 49. N.

ESSENCE, in *Metaphysics*, that which constitutes the particular nature of each genus or kind, and distinguishes it from all others.

ESSENES, or ESSENIANS, in Jewish antiquity, one of the three ancient sects amongst that people. They believed in a future state, but denied a resurrection from the dead. Their way of life was singular, inasmuch as they did not marry, but adopted the children of others, whom they bred up in the institutions of their sect, and, despising riches, had all things in common, never changing their clothes till these were entirely worn out. When initiated, they were strictly bound not to communicate the mysteries of their sect to others; and if any of their members were found guilty of enormous crimes, they were expelled. Pliny tells us that they dwelt on the western side of Lake Asphaltites; that they were a solitary kind of men, living without women or money, and feeding upon the fruit of the palm-tree; and that they were constantly recruited by new-comers, whom ill fortune had made weary of the world. The reason why we find no mention made of them in the New Testament may be their recluse and retired way of life, no less than their great simplicity and honesty, in consequence of which they did not lie open to censure or reproof.

ESSENTIAL, something necessarily belonging to a thing, and from which it cannot be conceived as distinct. Thus the primary qualities of bodies, such as extension, figure, number, and so on, are essential or inseparable from them in all their changes and alterations.

ESSENTIAL OILS are such as are really contained in a plant, and are drawn from it by distillation. They are so called in contradistinction to empyreumatic oils.

ESSEQUIBO, a river of English Guiana, in South America, which discharges its waters into the Atlantic. Long. 58. 30. W. Lat. 7. N. At its mouth it is twenty miles broad, but of difficult navigation, even for small vessels, on account of the numerous sand-banks which run in different directions across its entrance. There are three islands at the mouth of the river, and for nearly thirty miles upwards there is a succession of islands. The influence of the tide is felt for a hundred miles up the river.

ESSEQUIBO, a settlement of Guiana, on the banks of the above-mentioned river. The country is well cultivated and flourishing, the soil being fertile in the production of coffee, cotton, cocoa, and sugar. Essequibo originally belonged to the Dutch, and was first settled in 1698; but an erroneous prejudice that the land was unfit for cultivation obstructed the progress of the colony for many years. Political struggles, and the injudicious policy of the mother country, also for a considerable time deprived the colonists of the advantages which the country presented to them. During the American war it more than once changed masters, but it was finally ceded to Great Britain at the peace of 1814, since which period it has advanced in prosperity. It is separated on the west from Demerara by the small river Borasierri.

ESSEX, a county of England, is bounded on the south by the river Thames, on the east by the German Ocean, on the north by the counties of Suffolk and Cambridge, and on the west by Hertfordshire and Middlesex. Its surface contains 1473 square miles, according to the last measurement of the Board of Ordnance. The population has not increased in this county at the same rapid rate as that of the other counties of England, having been 226,437 in 1801, 252,473 in 1811, 289,424 in 1821, and 317,200 in 1831. As the surface is about 942,720 acres, there is nearly one person to every three acres; but if the rivers and large estuaries be deducted from the calculation of extent, the population may be stated as still more dense.

Essex may be considered as a mere agricultural county; for though, from the near approach of one part of it to the metropolis of the kingdom, there are some manufactories established, which find both their raw materials and their consumption in London; and though in one district of the county there are remains of the once extensive manufactories which were brought from Flanders to this island; the number of persons occupied in them bears but a very small proportion to that part of the population which depends on agriculture. The former manufactures of Colchester baizes for the Spanish and American markets have wholly disappeared, and those for woollen goods at Bocking, Halsted, and Coggeshall, are nearly extinct; all having removed to the northern parts of the kingdom. On the eastern side of the county, in the vicinity of the metropolis, are several large distilleries, and some establishments for bleaching and printing calicoes. There are also manufactories of sal-ammoniac, of Prussian blue, of iron liquor for calico-printers, and some other chemical preparations. There is a considerable trade in corn, and much barley is malted for the great breweries and distilleries. The only other commerce is that of supplying the inhabitants with foreign and domestic articles of luxury.

Although nearly half the county is bounded by the sea, or by navigable rivers, it carries on no foreign commerce; and what vessels belong to it are employed either in conveying to London the produce of its agriculture, or in the oyster fishery, which occupies a considerable tonnage and many seafaring persons. The oysters are bred both in the river Coln and in the Crouch; in the former they are protected by the seignorial rights of the corporation of Colchester, and in the latter by the proprietor of that river, Sir Henry Mildmay. The spawn is deposited in the months of April and May; and it is said the shell about it begins to form within twenty-four hours. The fishermen are forbidden to dredge for them at this season. In the month of July the dredgers separate the small oysters from the stones on which the spawn was deposited, and on which they have grown, and lay them down in the channels of the river till they grow of a size fit for consumption, which is determined by a gage kept for that purpose by the water-bailiff of Colchester. The stones or other substances to which the young oysters had adhered are again thrown into the water whence they were taken, as it is apprehended the accumulation of the ouse at the bottom of the river would otherwise generate such an increase of muscles and cockles as would destroy the breed of oysters. The number of vessels of different sizes employed in this branch of industry, from ten to forty tons burden, amounts to nearly three hundred, and the quantity of oysters caught, varying in different years, is from 18,000 to 24,000 bushels. The larger description of vessels are employed during part of the year on the shores of Hampshire and Dorsetshire in dredging for the native oysters, which are afterwards deposited in the beds of Essex and Kent, in order to fatten for the London market. The uncertain produce of the breeding grounds in Essex makes it necessary to have recourse to the more distant coasts to obtain the requisite supply.

From being almost wholly an agricultural county, the far greater part of the inhabitants of Essex are found in villages. The principal places, with their population, according to the late census, is as follows:

Colchester	16,167
Chelmsford	5,435
Walthamstow	4,258
Harwich	4,297
Saffron-Walden	4,762
Halsted	4,637
Romford	4,294
Maldon	3,831
Bocking	3,128
Coggeshall	3,227
Barking	3,404
Braintree	3,422
Waltham Abbey	4,104

Besides these, the towns of Witham, Dunmow, Harlow, Prittlewell, Finchingfield, Sible-Hedingham, Hornchurch, and Thaxted, each now contain more than 2000 inhabitants.

The face of the county is generally very beautiful; it is well enclosed, and for the most part displays good verdant pastures; the hills, none of which rise to great heights, are cultivated to the tops; and there are abundance of trees, especially oak and chestnut, which give a rich appearance to the view. There is no county in England in which the proportion of waste land is so small. The forests and wastes can indeed scarcely be considered as utterly uncultivated, and the whole of them do not amount to more than 14,000 acres, including the two forests of Epping and Hainault. These belong to the crown, though the inhabitants of many surrounding parishes have the right of pasturing their cattle upon them. The king has an unlimited right to keep deer on all the enclosed woods, and the occupiers of land in the various parishes included within the ancient boundaries of the forests have a right to feed horses and cows, but not other cattle. The numerous common rights have led to considerable devastation of the timber of these forests, and occasioned no small injury to the property of the crown; but plans have lately been adopted for preserving the trees, and converting a part into a nursery for growing timber for the royal navy. The vicinity to navigation makes these forests well deserving of being appropriated to this purpose.

That part of Essex which lies on the banks of the Thames, and on the shores of the ocean, is a rich alluvial soil on a subsoil of very tenacious clay. It produces, with good cultivation, most abundant crops of wheat, beans, oats, and clover. It is found necessary to the cultivation to fallow very frequently, and repeated ploughings is a practice very generally adopted. The swing plough is much used, and sometimes a wheel plough drawn by two, and occasionally by three horses abreast, which are guided with long reins by the ploughman. In fallowing it is common to plough the land six or seven times, and it is not unusual with the best cultivators to plough it eight or even ten times. After the summer fallow, by which the soil becomes completely pulverized, and rendered as fine as a garden, it is sometimes the practice to sow wheat in the autumn; but it is more common to let it remain throughout the winter, and then, after a spring ploughing, to sow barley or oats. The rotation of crops which usually succeed to a fallow is, 1. barley or oats; 2. clover, red or white, mostly the former; 3. wheat; 4. beans, twice hoed at least; 5. wheat. After this course the land is again fallowed. The whole produce of the course of crops is said to depend on the accuracy and skill exercised in the process of fallowing.

There is in this district some land adapted for turnips, and the rotation on such soils is usually, 1. turnips; 2. oats or barley; 3. clover; 4. wheat; 5. beans; 6. wheat. These courses are occasionally varied, tares being introduced when the clover fails, and peas being sometimes substituted for beans. The best cultivators often omit the second crop of wheat, and fallow again after the beans. A rotation which is sanctioned by some very skilful agriculturists is the following: 1. fallow; 2. barley or oats; 3. clover; 4. beans; 5. wheat; 6. tares or peas; 7. wheat. In this case the manure is laid on the clover ley for the bean crop. In the district we are describing all the farms have a portion, more or less extensive, of rich marsh land, on which oxen are fed, which supplies hay for winter consumption, and is consequently the source whence the manure is derived. The best wheat that is brought to the market of the metropolis is raised in the part of Essex of which we are speaking, and which is usually denominated the *hundreds*. It has the convenience of water-carriage to London; the rent of land is comparatively low, and it is of extraordinary fertility; but it suffers from a scarcity of good water. It is, especially in the autumn, a very agueish county; and though of late the roads have been much improved, they are still in such a state as, added to its insalubrity, prevents the gentry from residing on their estates.

The middle part of Essex rises above the level of the marshy lands, but partakes, in a considerable degree, of their unhealthiness. Around the town of Colchester, for a considerable distance, the soil is a dry loam, well calculated for turnips; and then the most general system adopted is the four-course husbandry of Norfolk, viz. turnip, barley, clover, and wheat. A variation is in some instances introduced by taking a crop of peas after the wheat, and occasionally tares are sown after the barley instead of clover, as that latter plant will sometimes fail if too frequently repeated. The greater part of the district is, however, of a clayey loam, on a subsoil of clay, and too tenacious for the turnip system. Much of this is good old pasture land, used solely for feeding, and to which the plough is never applied. The arable land is highly productive; the crops of wheat and beans especially are very luxuriant, and their produce of the best quality. The practice of fallowing is pursued as in the district before described, but so many ploughings are not deemed necessary. The rotation is various, but it rarely occurs that wheat is sown immediately after the fallow. Most commmonly the succession is as follows: 1. fallow; 2. barley; 3. beans; 4. wheat; 5. tares; 6. barley; 7. clover. When the land is more wet, which, in spite of excellent draining, is frequently the case, the rotation is, 1. fallow; 2. oats; 3. clover; 4. wheat. When manure is abundant, the heavy soils are cropped in the following rotation with great success: 1. fallow; 2. beans; 3. wheat; 4. tares; 5. barley; 6. clover; 7. beans; 8. wheat. In this rotation the clearing of the ground from weeds depends on the use of the hoe, which is applied most carefully to the crops of beans.

The western part of the county, especially where it borders on Hertfordshire, is, in general, land of a very inferior quality, and, without very expensive cultivation, yields but light crops. In one extensive district, called the Rodings, is still practised a most singular system of husbandry, known now in Essex only, though formerly it was adopted on poor lands in some other counties. It is, 1. a year's fallow; 2. wheat; 3. fallow; 4. barley, and then a repetition of the same course; thus having one half the arable land constantly without any crop. The soil is a tenacious clay, of a reddish colour, upon a subsoil of white clay. It is difficult to pulverize, and, with wet, potches so much as not to admit of ploughing when the atmosphere is moist. There are but small parts of this district which produce clover, peas, tares, or beans; and what hay is grown is confined to the narrow borders of the rivulets which run in the valleys.

In the south-western part of the county the agriculture assumes that system which is adapted to the supply of the wants of the metropolis. A great portion of the land is in permanent pasture, or grows hay to furnish the markets of Smithfield and Whitechapel. The arable land is generally cultivated with a rotation of three crops, viz. potatoes, wheat, and clover; and, as London supplies abundance of manure, by applying it very liberally to the young clover, after the wheat is harvested, such culture produces most abundant crops, and the land is cleaned by the potato culture. In this kind of husbandry, which, indeed, can only be conducted where manure is to be obtained with great facility, the plough is only used once in the rotation after the clover; as the potatoes are planted, and the digging them up sufficiently prepares the land for wheat.

Essex feeds some sheep, but very few are bred in the county. Calves are suckled to a great extent, and the rearing them to furnish veal for the London market is the principal dependence of many farmers. The whiteness of the veal is produced by a great attention to cleanliness, by regular periods of suckling, and by giving them a small portion of barley-meal mixed with chalk. The tendency to fatten is promoted by administering narcotic drugs, which keep the young animals in a quiescent state. Though the county affords such abundance of excellent pasture, yet the fattening of calves is so much more profitable than the dairy, that it is supplied with butter from other counties. Epping has indeed been celebrated for its excellent butter; but the greater part of what is sold in London under that denomination is the produce of Northamptonshire, Buckinghamshire, and other counties. London is supplied with much of its beef from Essex. The bullocks, in a lean state, are brought from Scotland, from Wales, and some from Devonshire, and are fattened in this county, sometimes on the rich natural meadows, and sometimes on turnips, with the addition of oil-cake.

Several other agricultural productions are cultivated in Essex. Hops are grown near Chelmsford, and in a few other districts. Saffron is cultivated near Saffron-Walden with great success. Mustard is an advantageous crop in the islands of Foulness and Wallasea, and on the embanked marshes. On some rich old pasture land, when first broken up, three crops are raised together, viz. carraway seed, coriander seed, and teasels for the baize manufacturers. The three kinds of seed are sowed together in the spring of the year. The harvest of the coriander takes place in the following autumn. The carraway is a biennial plant, and the seed is fit to be gathered in July of the succeeding year; and in September of the same year the teasels are cut. The carraway sometimes produces a crop the second, or even the third year. This cultivation is deemed an excellent preparation for the growth of wheat, on lands which are so prolific as to require some degree of exhaustion, as, the hoe being very liberally applied in the process of this triple cropping, it keeps the ground free from weeds. There are few counties in England, taking the whole of them together, in which the agriculture is so skilfully conducted, or where the productiveness is so great.

The landed property in Essex, as in other counties near to the metropolis, is very much divided; there are no overgrown estates, though some of considerable value, belonging to a few individuals; but the greater part is in moderate-sized farms, which can be easily disposed of, and which are frequently purchased from the savings of the commercial class in London.

The only good harbour in this county is Harwich, whence the packets for Holland are dispatched, and where there is a royal dock-yard, in which some frigates are built and repaired. The river Coln is navigable for small vessels to Colchester, and the Blackwater river to Walden. The Crouch is navigable for the largest ships; but, passing through an unhealthy country, and having few inhabitants on its borders, it is useless for the purposes of commerce. The river Lea is navigable by barges a distance of twenty-five miles. There are no canals in this county, but one is projected to unite the river Lea with the Cam, and thus create internal navigation from Lynn to London.

This county gives the title of earl to the family of Capel, and of Rochford to the family of Nassau; that of Baron Colchester to the family of the late Speaker of the House of Commons, Abbot; and that of Baron Western to the late representative of the county.

The members of the House of Commons elected in Essex are ten, being two for each of the boroughs of Colchester, Harwich, and Maldon, and four for the county, which, for election purposes, has been divided into the northern and southern districts. The polling places of the former are Braintree, Colchester, Saffron-Walden, and Thorpe; and of the latter, Chelmsford, Billericay, Romford, Epping, Rochford, and Maldon.

The most remarkable seats of noblemen and others are Audley-End, Lord Braybrooks; Thorndon, Lord Petre; Wanstead, now dilapidated, Hon. William Wellesley Pole; Easton Lodge, Lord Maynard; Felix Hall, Lord Western; Mistley Hall, C. Manners Sutton; Dagenham Park, Sir Thomas Neave; the Hyde, Theo. Disney, Esq.; Chigwell, Sir Eliab Harvey; Hill Hall, Sir William Smyth; Cranham Hall, Lady Davy; Weald Hall, Christopher Tower, Esq.; Boreham House, Sir John Tyrell; Coped Hall, Mr Conyers; Mark Hall, Mr Arkwright; Stansted Hall, Mr Fuller Maitland; and many others.

Essex, a post-town in Essex county, New York, on the western shore of Lake Champlain. It is fourteen miles south-west of Burlington, and sixteen miles from Elizabethtown. In this township there is a village situated on the lake, which is very flourishing, and enjoys a considerable trade. Essex is the name of several counties in the United States, which will be found described as they occur under the heads of the respective states.

ESSLINGEN, a city of the circle of the Neckar, in the kingdom of Wirtemberg, capital of a bailiwick of the same name. It is situated on the river Neckar, in a fertile district, and contains five churches, 980 houses, and 5591 inhabitants, who carry on woollen and cotton manufactures by machinery. Long. 9. 13. 25. E. Lat. 48. 44. 27. N.

ESTAIRES, a city of France, in the department of the North, on the navigable river Lys. It is an ill-built manufacturing town, producing table-linen, lace, and other goods, with 557 houses, and 5913 inhabitants.

ESTACHAR, Estaker, or Istakhar, a town of Persia, in the province of Kuzistan, near to which are the ruins of the celebrated city of Persepolis. It is thirty miles north-north-east of Schiraz, and 160 south-south-east of Ispahan. Long. 53. 40. E. Lat. 30. 5. N.

ESTAMBOLIC, or Istambel, a town of Arabia, in the jurisdiction of the schereef of Mecca, near the coast of the Red Sea. It is 180 miles north-north-west of Medina.

ESTATE, in *Law*, signifies the title or interest which a person has in lands, tenements, or other effects. A fee-simple is the amplest estate the law admits of.

Estates, in a political sense, is a term used to denote either the dominions of some prince, or the general classes into which the people are divided.

In Britain, the estates are the king, lords, and commons; or rather the lords and commons, who meet the king in parliament, for the purpose of reforming abuses, and enacting good and wholesome laws.

ESTE, a city of Italy, in the Austrian government of Venice, situated on the canal of Monfelice. It is fortified, and contains a cathedral, several palaces, and 7534 inhabitants, who carry on a brisk trade in spinning silk and making silk goods. It is rich in antiquities, and is the place whence originated the family which at present sits on the British throne. Long. 21. 25. 30. E. Lat. 45. 31. 21. N.

ETAWEH, a town and fortress of Hindustan, in the province of Agra, and capital of a district of the same name. It is situated on the eastern bank of the Jumna, many parts of which, during the dry season, are sixty feet in height. The town is built on the heights, and, as it approaches the river, is divided into separate hills by deep ravines. It was formerly the residence of a rajah, and a place of considerable consequence; and it still carries on a considerable traffic in grain, sugar, and cotton. There is also an extensive manufacture of coarse cotton cloths in the vicinity. It is now the station of the civil establishment of the district. Long. 78. 58. E. Lat. 26. 46. N. The district is situated in the Doab, or between the Ganges and the Jumna, and about the 27th degree of north latitude; and, with the rest of the Doab, it was ceded to the British by the nabob of Oude in 1801.

ESTELLA, a city of Spain, upon the Ega, in the province of Navarre, containing 4600 inhabitants. It possesses an old castle and a college. Many distilleries of brandy and wine are carried on here, as well as a manufactory of cloth, which supplies the army.

ESTEPONA, a small town on the shores of the Mediterranean Sea, in the province of Granada, in Spain. It contained nearly 5000 inhabitants before the ravages of the epidemic fever in 1804, which almost desolated the coast on which it stands. On this occasion it lost one third of its inhabitants. The principal occupation of the people consists either in fishing, or in cultivating fruits of various kinds, and conveying them to the British garrison of Gibraltar; in making earthenware and bricks; and in the manufacture of linen, which employs twenty looms.

ESTHER, a canonical book of the Old Testament, containing the history of a Jewish virgin, dwelling with her uncle Mordecai at Shushan, during the reign of Ahasuerus, one of the kings of Persia. The great beauty of this Jewish maiden raised her to the throne of Persia, by which means she had an opportunity of saving her countrymen, whose destruction had been plotted by Haman, a favourite of Ahasuerus.

The learned are not agreed as to who this Ahasuerus was. Archbishop Usher supposes him to have been Darius Hystaspes, and Artystona Esther. Scaliger makes him the same with Xerxes, and supposes his queen Hanestris to be Esther; but Josephus, on the contrary, positively asserts that the Ahasuerus of the Scriptures is the Artaxerxes Longimanus of profane history; and the Septuagint, throughout the whole book of Esther, translate Ahasuerus by Artaxerxes. Most people subscribe to this last opinion; and indeed the kindness which Artaxerxes showed to the Jews can scarcely be accounted for otherwise than by supposing that that people had so powerful an advocate as Esther to plead in their behalf. It may be observed, however, that the ancient Persians, who were singularly intolerant of idolatry, and the fierce destroyers of idols, wherever such were to be found, might, for this reason, be supposed favourable to a people whose religion admitted not graven images, and who, like themselves, were pure theists.

ESTHONIA, or ESTHLAND, a province of the Russian empire, on the Baltic Sea, extending over 7106 square miles. It is divided into four circles, viz. Revel, Hapsal, Weisenstein (formerly Jerwen), and Wesenburg (formerly Wierland). It contains five cities, one market-town, forty-seven parishes, and 630 estates of nobles, with 30,000 peasants' dwellings. The whole population amounts to 412,000 persons. It is a level and generally a sandy district, but mixed with portions of clay and stones. It is full of brooks and morasses. As agriculture is the chief employment, the land produces rather more corn, chiefly rye, than is required for the consumption. The fishery occupies a number of hands. The manufactures are of a domestic kind; and, during the long winters, coarse linen and woollen cloths are spun and woven for their own clothing in each family. The capital, Revel, is the chief place of foreign trade, from which is exported corn, spirits, butter, salted fish and flesh, and tallow, with a small quantity of flax and flax seed.

ESTOILEE, or CROSS ESTOILLEE, in *Heraldry*, a star with only four long rays in the form of a cross, and accordingly, broad in the centre, but terminating in sharp points.

ESTOPPEL (from the French *estouper*, *oppilare*, *obstipare*, to stop or block up), in *Law*, an impediment or bar of action, arising from a man's own act or deed.

ESTREMADURA, a province of Spain. It is bounded on the north and east by New Castille, on the south by Andalusia, and on the west by Portugal; the southern part being divided from that kingdom by the river Guadiana. It is the most thinly peopled of any part of the kingdom except Cuença, and the density of its population very little exceeds that province. Its extent is 1199 square leagues, and its population amounts to 428,493 souls. The soil in general is fruitful, and produces vines, oil, hemp, silk, corn, and fruits. Its mountains abound in chestnuts, in oaks, and the other timber trees. Its pastures feed large flocks of sheep, both of the migratory and fixed breeds. The breeds of horses are excellent; and the pigs are celebrated throughout Spain, the hams and sausages made from them being preferred to all others. In spite however of the capacity to yield these valuable productions, much of the land is uncultivated, and many parts of it are without inhabitants. The backward state of the agriculture is generally attributed to vast tracts of land, susceptible of the best cultivation, being destined solely to the pasturage of the Merino flocks. As the pastoral life requires but few labourers, and extensive open fields, where sheep flocks are managed so very injudiciously as they are in Spain, it has a tendency to check the increase of population and cultivation. The northern part of this province extends to the banks of the Tagus, into which, after their junction, run the two rivers of that district. These are the Xerte and the Alagon. The middle of the province, between the upper part of the Guadiana and the Tagus, is a very dry country, with no great and few small streams. The southern part has the river Guadiana, a muddy and often stagnant stream, and some tributary rivers. It is the best cultivated part, but between it and Seville are ranges of mountains, which hold out little inducement to any other system of farming than that of feeding sheep for the sake of their valuable fleeces. There are some mines of silver and of platina in this southern division of the province. The yearly produce of this province is 6000 cwt. of pepper, 5925 of flax, and 875 of hemp; of wine 4376, of brandy 53,125, of vinegar 1000 ohms; of oil 50,259, of sumach 9800, of madder 45, of woad 100, and of silk 204½ cwt. The annual produce of honey is 3375, and of wax 600 cwts. In manufactories of cloth there are employed 726, and of linen 2168 looms. There are also 155 tanneries, twenty-five hat manufactories, and seventy-three soap-boiling houses.

ESTREMADURA, a province of Portugal, the only one in that kingdom which does not in some of its borders join to Spain. Though Lisbon and its great population forms part of this province, it is not so thickly peopled as either Entre-Douro-e-Minho or La Beyra. Its extent is 823 square leagues, and its inhabitants amount to 826,680 souls. The province of La Beyra surrounds Estremadura, excepting where the sea or the river Tagus are its limits. The soil produces some wheat, maize, and millet, much wine and oil, and abundance of fruits and culinary vegetables. Its shores abound with fish, as well as the fresh-water rivers. On the coast great quantities of salt are made by the evaporating power of the sun alone, and consequently much cheaper and better than in our more northern climate. The only river besides the Tagus that runs into the sea is the Lis, which empties itself near Leyria. The Tagus, which crosses Estremadura, has its course so interrupted by rocks and cascades, as to be incapable of navigation above Abrantes; but from that city to Lisbon, a distance of thirty leagues, shallops regularly navigate. The right bank, after the Tagus enters Portugal, is mountainous; but the left bank is marshy, sterile land. From Santarem there is a constant gradual declivity to the city of Lisbon, and, though fourteen leagues asunder, the capital may be seen from the former city. The rivers which from the north increase the waters of the Tagus, are the Pouzut, the Lysa or Laca, and the Cecere. These descending from the mountains of La Beyra, have an unequal and sometimes dangerous degree of rapidity, being at one time mere rivulets, almost dry, and at others rapid torrents, which inundate the country; but when they do so, they afford means of defence against an invading enemy. Some ranges of high mountains run northward from the Tagus towards Busaco. One spot in these will be long celebrated. The lines of Torres Vedras will not be forgotten as the place where Lord Wellington made his successful stand, and caused to roll back on the invaders the desolation they had spread in their advancing course.

ESZEK, a city of the Austrian kingdom of Hungary, in the province of the Farther Theiss, and the capital of a circle of its own name. It is situated on the river Drave, is strongly fortified, and defended by a citadel. It is a place of considerable trade in corn, cattle, and hides, and contains three Catholic and one Greek church, with 10,850 inhabitants. Long. 18. 36. 45. E. Lat. 45. 34. 13. N.

ETAMPES, an arrondissement of the department of the Seine and Oise, in France, extending over 380 square leagues, divided into four cantons and 101 communes, and containing 37,922 inhabitants. The capital, of the same name, is situated on the river Juine, in a most delightfully fruitful neighbourhood. It contains 982 houses, and 7198 inhabitants, who make hats, caps, and hosiery, and dress much leather. Long. 2. 1. E. Lat. 48. 25. N.

ETCHING, a method of engraving on copper, in which the lines or strokes, instead of being cut with a tool or graver, are eaten in with aquafortis. See ENGRAVING.

Etching, though not very modern, is of later invention than engraving with the tool, of which it was at first only an imitation, practised by painters and other artists, as they could much sooner form their hands to, and attain a facility of, working in this way than with the graver. But being nevertheless considered as a counterfeit kind of engraving, and therefore inferior to the other, it was cultivated in a very confined manner; the closeness of the resemblance of the work to that performed by the tool being made the test of its merit, and consequently the principal object of aim in those who pursued it. This servile restriction of the art of etching to the imitation of the original kind of engraving was a great cause of retarding its advancement towards perfection, as many of the most able masters cramped their talents by the obser-ance of so narrow a rule. This may be seen in the instances of Sadelers, Swaneberg, Villamena, and particularly Le Bosse, who, in his treatise on engraving, has laid it down as a principle, that the perfection of this kind consists in the close similitude of the work to that executed with the tool. But this absurd prepossession has been since worn out; and the method of working with aquafortis has been so far improved, that instead of being now deemed a spurious kind of engraving, it evidently appears, in many modern works, the foundation of an excellence that could never have been produced without it; since, though the neatness and uniformity of the hatches which attend the use of the tool is more advantageous with respect to portraits, yet the liberty and facility of the other manner gives a much greater opportunity to exercise the force of genius and fancy in historical engraving, where the effect of the whole, and not the minute exactness in finishing all the parts, constitutes the principal value.

There are two methods practised of engraving in this way; the one with a hard varnish or ground, and the other with a soft. The former was at one time much used, being better accommodated to the intention of imitating the engraving with the tool; as the firmness of the body of the varnish gave more opportunity of retouching the lines, or enlarging them with the oval-pointed needles, called by the French *echoppes*, as was practised by Le Bosse and others for that purpose. The latter has now almost wholly superseded the use of the other, by the free manner of working it admits of; which affords a power of expression incompatible with the greater inflexibility of the hard varnish, that confines the lines and hatches to such a regularity and sameness, as give stiffness of manner and coldness of effect to the work.

The combination of the use of the tool and aquafortis, which are now both employed in many cases, has, however, given that perfection to engraving which it at present possesses. The truth and spirit of the outline which the method of working with aquafortis affords, and the variety of shades which the different kinds of black produce in this way, as well as other means of expressing the peculiar appearance and character of particular subjects, furnish what was defective in the sole use of the tool; whilst, on the other hand, the exactness and regularity of the lines, which are required for finishing many kinds of designs, are supplied by the graver; and by a judicious application of both, that complete finishing is obtained which either of them alone must necessarily want.

The manner by which this is performed, is by covering the surface of the plate with a proper varnish, or *ground*, as it is called, which is capable of resisting aquafortis, and then scoring or scratching away, by instruments resembling needles, the parts of this varnish or ground, in the places where the strokes or hatches of the engraving are intended to be; then, the plate being covered with aquafortis, the parts which are exposed by removing the ground or varnish are corroded or eaten away by it, whilst the rest, being secured and defended from the action of the acid, remain untouched.

There are two methods of etching, as has been already observed, the difference of which consists as well in the kind of the varnish or ground as in that of the aquafortis adapted to each kind; but the general methods of performing them are alike in both cases. These varnishes or grounds are distinguished by the names of *hard* or *soft*; for in their consistence, or the resistance which they give to the needles, lies their essential variation from each other. The hard varnish, it is with good reason conjectured, was not the first in use, but soon took the place of the other, and was for some time the most received in practice, on account of its admitting the work to be made more like that of the graver; the soft has since, however, in its turn prevailed, to the exclusion in some degree of the hard, except in the case of particular subjects, but not so entirely as to take away the expediency of showing how it is performed. The manner of etching with the soft varnish is now, however, one of the most important objects of the art of engraving; and it is at present in universal use, sometimes alone, but more frequently intermixed with the work of the tool, and in some cases with great advantage, even where the whole is intended to pass for being performed by the graver.

Preparation of the soft varnish, according to Mr Lawrence, an eminent English engraver at Paris.—"Take of virgin wax and asphaltum each two ounces, of black pitch and Burgundy pitch each half an ounce. Melt the wax and pitch in a new earthenware glazed pot, and add to them, by degrees, the asphaltum, finely powdered. Let the whole boil till such time as that, taking a drop upon a plate, it will break when it is cold, on bending it double two or three times betwixt the fingers. The varnish, being then enough boiled, must be taken off the fire, and, letting it cool a little, must be poured into warm water, that it may work the more easily with the hands, so as to be formed into balls, which must be rolled up, and put into a piece of taffety for use."

It must be observed, first, that the fire be not too violent, for fear of burning the ingredients, a slight simmering being sufficient; secondly, that whilst the asphaltum is putting in, and even after it is mixed with them, the ingredients should be stirred continually with the spatula; and, thirdly, that the water into which this composition is thrown should be nearly of the same degree of warmth with it, in order to prevent a kind of cracking that happens when the water is too cold.

The varnish ought always to be harder in summer than in winter; and it will become so if it be suffered to boil longer, or if a greater proportion of the asphaltum or brown resin be used. The experiment above mentioned, of the drop suffered to cool, will determine the degree of hardness or softness that may be suitable to the season when it is used.

Preparation of the hard varnish used by Callot, commonly called the Florence Varnish.—Take four ounces of fat oil, very clear, and made of good linseed oil, like that used by painters; heat it in a clean pot of glazed earthenware, and afterwards put to it four ounces of mastich well powdered, and stir the mixture briskly till the whole be well melted; then pass the whole mass through a piece of fine linen into a glass bottle with a long neck, that can be stopped very securely; and keep it for the use that will be below explained.

Method of applying the soft varnish to the plate, and of blackening it.—The plate being well polished and burnished, as also cleansed from all greasiness by chalk or Spanish white, fix a hand-vice on the edge of the plate where no work is intended to be, to serve as a handle for managing it when warm; then put it upon a chafing-dish, in which there is a moderate fire, and cover the whole plate equally with a thin coat of the varnish; and whilst the plate is warm, and the varnish upon it in a fluid state, beat every part of the varnish gently with a small ball or dauber made of cotton tied up in taffety; which operation smoothes and distributes the varnish equally over the plate.

When the plate is thus uniformly and thinly covered with the varnish, it must be blackened by a piece of flambeau, or of a large candle which affords a copious smoke; sometimes two or even four such candles are used together, for the sake of dispatch, that the varnish may not grow cold; which if it does during the operation, the plate must then be heated again, that it may be in a melted state when that operation is performed; but great care must be taken not to burn it, which, when it happens, may be easily perceived by the varnish appearing burnt and losing its gloss. The following expedient is made use of for the more commodiously blackening the varnish, and is particularly necessary where the plates are large: Fix a strong hook in the roof of the room, through which pass four pieces of cord of equal length, at the end of which are fixed four iron rings of about four inches in diameter, for supporting the corners of the plate. The plate, being thus suspended in the air, with the varnished side downwards, may be blackened with great convenience; but this is not, however, absolutely requisite, excepting in the case of large plates, which could not, without difficulty, be suspended, unless this or some other such contrivance were made use of.

It is proper to be very cautious in keeping the flambeau or candle at a due distance from the plate, lest the wick should touch the varnish, which would both sully and mark it. If it appear that the smoke has not penetrated the varnish, the plate must again be placed for some little time over the chafing-dish; and it will be found that, in proportion as the plate grows hot, the varnish will melt and incorporate with the black which lay above it, in such a manner that the whole will be equally pervaded by it.

Above all things, in this operation, the greatest caution should be used to keep the fire all the time moderate; and to move frequently the plate, and change the place of all the parts of it, that the varnish may be alike melted everywhere, and kept from burning. Care must also be taken, that during this time, and even till the varnish be entirely cold, no filth, sparks, or dust, fly on it; for they would then stick fast and spoil the work.

Method of applying the hard varnish.—This is precisely the same as that for the soft; it is spread equally over the warm plate with the taffety-ball, and smoked in the same manner; only, after it is smoked, it must be baked, or dried over a gentle fire of charcoal, till the smoke from the varnish begins to decrease; taking care not to overheat the plate, which would both soften it and burn the varnish.

The plate being thus prepared, and an exact drawing of the outlines of the design made upon thin paper, the other side of the paper must be well rubbed with chalk or Spanish whitening, or, which is better, with red chalk scraped to a powder: the loose chalk is then cleared off with a linen rag, and the stained side of the paper is laid upon the varnish, fixing the corners to the plate with wax or wafers, to prevent its shuffling; and with a blunted needle or pointer the drawing is slightly traced, and communicates to the varnish an exact outline of the design to be etched.

A variety of pointers is necessary for the work. Those used for the broad large strokes ought to be very blunt, exceedingly round, and well polished at the point; the sole of a shoe answers very well for polishing the points. The finest ought to be as sharp as a needle. If any scratches or false strokes happen in the working, they are to be stopped up with a hair pencil dipped in Venetian varnish mixed with lamp black, by which means these places will be defended from the action of the aquafortis.

The next operation is that of eating or corroding the plate with aquafortis, in order to which a border of soft wax, being a composition of bees-wax melted and tempered with a little Venice turpentine and tallow, must be fastened round the plate about an inch high, in the form of a little wall or rampart, to contain the aquafortis. At one of the corners of this border a gutter is usually made, which serves for commodiously pouring the aquafortis off the plate. The plate being thus bordered, take a due quantity of the refiner's aquafortis, mix it with half its quantity of common water, and pour it gently on, till it rise above a finger's breadth above the surface of the plate; then, if all things have been rightly conducted, it will soon be seen that the aquafortis exerts its action in the hatches which have been strongly touched; but those more weakly engraved will appear at first clear, and of the colour of the copper. The menstruum must therefore be suffered to continue on the plate till its effects become visible on the more tender parts; then the aquafortis should be poured off, the plate washed with clean water, and dried before the fire; after which take a small pencil dipped into the Venetian varnish, and cover with it the lighter parts of the plate. This being done, the aquafortis must again be poured on, and suffered to continue a longer or a shorter time, according to the strength of the menstruum or the nature of the engraving; after which it must be poured off as before, and the plate immediately washed with water.

It may not be improper to observe, that, when the aquafortis is on the plate, a feather should be used to cleanse away the foulness of the verdigris that gathers in the hatches when the aquafortis operates on them, and to give it more room to exert its action; for by moving the aquafortis to and fro on the plate by the feather, and brushing away the black saline matter where it appears to be formed, the hatches will be cleansed, and the aquafortis exert its whole force equally on every part.

The plate being thus sufficiently corroded by the aquafortis, and well washed with water, it must be warmed at the fire, and the border of wax removed; after which it must be made hotter till the varnish melt; then it must be well wiped with a linen cloth, and afterwards rubbed well with oil of olives, when it will be ready to be retouched and finished by the graver.

ETELENT, a town of the Arabian Irak, on the river Tigris, 66 miles north-north-west of Bassora.

ETEOCLES, in fabulous history, a son of Œdipus and Jocasta. After his father's death, it was agreed between him and his brother Polynices that they should both share the royalty, and reign a year each alternately. Eteocles by right of seniority first ascended the throne; but after the first year of his reign had expired, he refused to give up the crown to his brother, according to their mutual agreement. Resolved to punish such an open violation of a solemn engagement, Polynices went to implore the assistance of Adrastus, king of Argos, received that king's daughter in marriage, and was soon afterwards assisted with a strong army, headed by seven famous generals. Whilst these hostile preparations were making, Eteocles on his part did not remain inactive. He chose seven brave chiefs to oppose the seven leaders of the Argives, and stationed them at the seven gates of the city; he placed himself against his brother Polynices, and opposed Menalippus to Tydeus, Polyphontes to Capaneus, Megareus to Eteocles, Hyperbius to Parthenopæus, and Lasthenes to Amphiaraus. Much blood having been shed in light and unavailing skirmishes, it was at last agreed between the two brothers that the war should be decided by single combat. An encounter accordingly ensued, and was conducted with such inveterate fury that both combatants fell; nay it is even pretended that the ashes of these two brothers, who had been so inimical to each other while living, separated on the burning pile, as if sensible of resentment, and hostile to reconciliation.

ETERNITY, an attribute of God, expressing his infinite or endless duration.

Eternity, in *Mythology*, a divinity among the Romans, who had neither temples nor altars, but who was represented under the figure of a woman holding the sun in one hand and the moon in the other. The symbols of this divinity were a phœnix, a globe, and an elephant.

ETESIÆ, or Etesian Winds, are such as blow at stated times of the year, from what point soever of the compass they come. They are so called from the Greek word ετος, *year*, being yearly or anniversary winds, such as are now called monsoons and trade-winds, which in some parts of the world continue constantly blowing in the same direction during stated seasons of the year. Thus the north winds, which during the dog-days constantly blow upon the coasts of Egypt, and prevent all ships sailing out of Alexandria for that season, are called *etesiæ* in Cæsar's Commentaries; and in other authors, the west and east winds are called *etesiæ* when these continue blowing for certain seasons of the year.

Cellarius endeavours to prove that those winds are properly etesian which blow from that part of the horizon which is between the north and west about the time of the solstice. In ancient writers they are represented as of a very mild and gentle kind; and are called *somniculosi* and *delicati*, from their sleeping or ceasing to blow in the night.

ETFU, or Edfou, a town of Upper Egypt, celebrated on account of the sublime temple of Apollonopolis, which, Denon observes (*Trav.* ii. 277), is "the most beautiful of all Egypt, and, next to those of Thebes, the largest. Being built," he adds, "at a period when the arts and sciences had acquired all their splendour, the workmanship of every part is equally beautiful, the hieroglyphics are admirably executed, the figures more varied, and the architecture of a higher order, than in the Theban edifices, the building of which must be referred to an earlier age. See article Egypt.

ETHER, an extremely volatile fluid, produced by the distillation of alcohol with an acid. See Chemistry.

ETHERIDGE, or Etherege, Sir George, a wit and comic genius in the reigns of Charles II. and James II. was descended from an ancient family in Oxfordshire, and born in 1636. He travelled in his youth; and, not being able to confine himself to the study of the law, devoted himself to the acquisition of lighter and gayer accomplishments. His first dramatic performance, entitled *Comical Revenge, or Love in a Tub*, appeared in 1664, and introduced him to the leading wits of the time; in 1668 he produced a comedy called *She would if she could;* and in 1676 he published his last comedy, called the *Man of Mode, or Sir Fopling Flutter*, which is certainly an elegant comedy, and contains much of the real manners of high life. This piece he dedicated to the Duchess of York, in whose service he then was, and who entertained so great a regard for him, that when, on the accession of James II. she became queen, she procured his being sent as ambassador first to Hamburg and afterwards to Ratisbon, where he continued until his majesty had quitted the kingdom. Our author being addicted to certain gay extravagances, had greatly impaired his fortune, in order to repair which, he paid his addresses to a rich widow; but the lady being ambitious, had determined not to condescend to a marriage with any man who could not bestow upon her a title; and on this account he was obliged to purchase a knighthood. None of our writers has exactly fixed the period of Sir George's death, though all seem to place it not long after the Revolution. Some say that on this event he followed his master King James into France, and died there; but the authors of the *Biographia Britannica* mention a report that he came to an untimely death by an unlucky accident at Ratisbon. Having entertained some company at his house, where he had taken his glass rather too freely, and being, through his great complaisance, forward in waiting on his guests at their departure, he is said to have tumbled down stairs, broken his neck, and thus fallen a martyr to mirth and jollity. As to the literary character of Etheridge, he seems to have possessed a genius the vivacity of which required little cultivation; for we have no proofs of his having made any attainments in scholarship. His works, however, have not escaped censure on account of that licentiousness which pervades and renders them dangerous to young unsophisticated minds; and the more so on account of the lively wit with which it is as it were gilded or lackered. The only prose production of Etheridge is a short piece entitled *An Account of the Rejoycing at the Diet of Ratisbonne, performed by Sir George Etherege, Knight, residing there from his Majesty of Great Britain; upon occasion of the birth of the Prince of Wales. In a Letter from himself.* Printed at the Savoy, 1688.

ETHICS, the doctrine of manners, or the science of moral philosophy. The word is formed from ηθος, *mos*, ηθη, *mores*, manners; because it is the object of ethics to investigate the manners or conduct of man. See Moral Philosophy.

ETHIOPIA, a name which, as vaguely applied by the ancients, comprehended all Africa south of Egypt, and of the mountain range of Atlas, including Nubia and Abyssinia, but which is, in its more restricted and proper signification, applied to the country which was bounded on the north by Egypt, on the west by Libya Interior, on the east by the Red Sea, and on the south by a part of Africa unknown to the ancients. (See articles Abyssinia and Africa.) Although this vast tract of country must at different times have varied in extent, particularly on the side of Libya Interior, where it had no definite or ascertained boundary, yet it seems for many ages to have comprehended the kingdoms of Dongola, Sennaar, and Abyssinia, with part of Adel or Zeila, to have extended seventeen degrees in longitude, and to have reached from the tropic of Cancer to within six degrees of the equator.[1] In a still more limited sense, the term Ethiopia was applied to the island of Meroë, included between the main branch of the Nile and the Astaboras or Tacazze, the capital of which was also called Meroë; and it seems to have formed no part of the country which is now denominated Abyssinia. This region, which conquered Egypt, and which Cambyses, after having subdued that country, vainly sought to conquer, was long involved in mystery; and there is no record of its having ever been reached by any land expedition. Neither Petronius when sent by Augustus against Queen Candace, nor Probus in his expeditions against the Blemmyes, penetrated as far as Meroë; and, in fact, it is only in recent times that the dark cloud under which it was so long hid has been dispelled by the hardy enterprises of Burckhardt and Caillaud, particularly the latter. (See article Abyssinia, and Heeren's *Historical Researches.*) To Ethiopia proper the ancients gave various other names, an enumeration of which will be found in the seventh volume of the *Universal History*, part second, London, 1744, folio.

ETHIOPIAN NATIONS. A great many nations, different and distant from one another, were formerly comprehended under the denomination of Ethiopian. In ancient times the natural history of man was but little cultivated. Nations were distinguished according to the most obvious difference in their appearance, namely, their colour; and all who presented the most striking contrast to Europeans, either by a very dark or completely black skin, received the appellation of Ethiopians. Hence we find Ethiopian nations scattered over a considerable part of the ancient world; and although Africa certainly contained the greatest number of these, yet they were by no means confined to that continent alone. A considerable tract of Asia was occupied by an Ethiopian race; and as India was often made to comprehend southern Africa, so, in like manner, Ethiopia was made to include southern India. But it is of importance that the extent of these nations, and the various seats occupied by them, should be more accurately defined.

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[1] *Universal History*, vol. vii. part 2d, p. 180. London, 1744, fol.

Anciently the native tribes of Africa were divided into two distinct classes; the Libyans and the Ethiopians. "Four nations," says Herodotus, "occupy Africa, and no more; two of which are aboriginal, and two not. The Libyans and Ethiopians are aboriginal, the former being situated northward, and the latter southward in Libya; the foreign settlers are Phœnicians and Greeks." This division was exactly followed by succeeding writers. Under the name of Libyans the father of history comprehended all the nations inhabiting northern Africa, exclusive of the Carthaginians and Greeks, the separate tribes which extended as far as the Lesser Syrtis, and the nomadic tribes of north-western Africa. But the question as to who these nations were, and whether any of their descendants may now be discovered, cannot be answered without difficulty, owing to the changes which the migratory invasions of the Arabs have produced in northern Africa. The narratives of modern travellers, however, have made us acquainted with two nations altogether different from the Arabs and negroes; we mean the Tibboos and the Tuaricks. They dwell to the south and west of Fezzan, their territory being bounded on the south-east by Bornou, on the south by Nigritia, and on the west by Fez and Morocco; they are divided into many tribes, all speaking the same language, which is different from the Arabic; their lineaments have nothing of the negro character or contour; and their colour, which seems to vary in tint according to their place of abode and mode of life, is of almost every shade and hue between white and black. The Tuaricks, in particular, are described as a very fine race of men; tall, straight, and handsome, with an air of independence. They are generally white, though in their complexion considerably tanned by the climate, and their arms and bodies are as fair as those of many Europeans. Their language is the Breber, or original African tongue; they inhabit the immense tract denominated the Sahara or Great Desert; they are of numerous tribes, some of whom wander like the Arabs; and they subsist chiefly by plunder. The Tuaricks travel on the maherri or dromedary, by means of which they perform long journeys in an incredibly short space of time; and many of their tribes are at perpetual war with the Soudan states, from which they carry off great numbers of slaves, the principal article of their trade. The nearest place of this people is about ten days' journey to the south of Mourzouk.

The Tibboos are in every respect a different people from the Tuaricks. Their colour is of the brightest black, but their profile has nothing of the negro character; they have aquiline noses, fine teeth, and lips formed like those of Europeans; in civilization they are below the Tuaricks, living partly in caves and partly in villages situated upon barren rocks or hills; and they follow the slave trade, but do not trade to Soudan. From a comparison of the Tuaricks and Tibboos, Heeren has been led to conjecture that the former spread from north to south, and the latter from south to north. But it is nearly as difficult to draw an accurate line of demarcation between these tribes and those of the negro race, as between the ancient Libyans and Ethiopians. It is no doubt true that the southern boundaries of the Great Desert may in general be taken as the limits of the negro countries; but, on the other hand, it is certain that separate black tribes, whether completely negro or not, have both in ancient and modern times penetrated a considerable way into the Sahara or Great Desert. From Lyon's map we learn that at present the black population commences about the twenty-eighth degree of north latitude. The circumstance mentioned by Herodotus, of the Ethiopians having been hunted by the Garamantes in four-horse chariots, and the detached tribes of this people which dwelt along the Atlantic coast almost as far as Cerne, show that this was also the case in early times; and from the narratives of modern travellers we collect that, in the Tibesti Mountains, the same territory where the Garamantes hunted the Ethiopians, black tribes are still to be found. If, then, the numerous interminglings of these tribes which must necessarily have taken place in a long course of ages, and the circumstances which, in a country like Africa, are continually occurring to produce changes and migrations, together with the ordinary operation of physical laws, be all duly considered, the difficulty, if not the impossibility, of drawing an accurate boundary line between the Libyans and Ethiopians, will easily be perceived.

So much for the western nations of northern Africa. With regard to the eastern, the inhabitants of the banks of the Nile above Egypt, and of the adjacent countries as far as the Arabian Gulf; as their country in general is comprehended under the name of Ethiopia, the denomination has been transferred to its inhabitants, who have received the name of Ethiopians, not by reason of their descent, but simply because their complexion happens to be dark. Herodotus classes the Ethiopians according to the growth of their hair, and particularly distinguishes the negroes from the other swarthy tribes. "The Asiatic Ethiopians," says he, "have straight hair; whilst the African Ethiopians have the most curly hair of all men." But, as we have already seen, he is mistaken in speaking thus of all the black tribes of Africa, some of whom are not negroes, and, notwithstanding the black hue of their skins, have straight hair. He judged according to what he saw of them in Upper Egypt, the most southern point of his travels; but, from not having penetrated farther into the interior of the African continent, he judged erroneously. We are, however, indebted to him for one important piece of information, namely, that the eastern districts of northern Africa, presently comprehended under the names of Nubia and Sennaar, were then occupied by two distinct races; one aboriginal, which he includes under the general appellation of Ethiopians; and the other immigratory, of Arabian origin, and leading for the most part a wandering life. That such was actually the case during the Persian period, and even as far back as the times of the Pharaohs, there are many proofs; and we shall soon see how the statement in question tallies with the accounts of recent travellers. But still it would be as difficult to draw a precise line of distinction between the Arabian and aboriginal nations here, as between the negroes and Berbers in western Africa; more especially as many of the immigratory tribes have intermingled with the elder stock, and as the latter lay claim to an Arabian descent, which they have been led to consider as the more honourable. Language, however, if due caution be used in examining it, forms the most certain test, and indeed may be considered as decisive on this point. For as it is improbable that the Arabians, who pride themselves on their language, would ever relinquish it in order to adopt that of a barbarous or conquered people; so, on the other hand, all those nations who do not speak Arabic may be ranked as aboriginal, whatever descent their traditions may claim for them; and hence all of them may be included under the general appellation of Berbers or Barabras, a name which, in the same sense, is still applied to them in Egypt, if not in other countries.

Amongst these nations the first place is due to the Nubians, who live in a land of monuments, perhaps erected by their forefathers, and who, on that account, have greater claims on our attention. This name does not occur until the age of the Ptolemies, and is first mentioned by Eratosthenes; but it soon came into use as the general denomination of all the tribes living on both sides of the Nile from Egypt to Sennaar, and the ancient Meroë, and sometimes, in a more limited sense, as applicable only to the inhabitants of the present Dongola. The Nubians are distinguished by this, that their dwellings are in the valley of the Nile, amidst numerous monuments of ancient splendour and civilization. They speak a language entirely different from the Arabic; they are of a dark-brown colour, with hair either naturally curly or artificially arranged, but not at all woolly, and often formed into an elevated ornament, as in the figures on the monuments; and their visage has nothing whatever of the negro physiognomy. The men are well formed, strong, and muscular, with fine countenances, but are something shorter in stature than the Egyptians; they have only a little beard growing under the chin, as in the Egyptian statues; they are thinly clad, indeed almost naked; and they are all armed with a spear, a dagger, and a large shield formed of the hide of the hippopotamus. The women are well made, with very pleasing features; and, as they are usually bought of their parents, they frequently intermarry with the Arabs. But the distinctive characteristics of race have not thereby been destroyed. The Nubian has more courage and daring than the Arab; and his beauty is as unchangeable as that of a statue in a rock temple. At Dongola the language chiefly in use is the Nubian, the Arabian being but imperfectly understood. To the south of Dongola is the country of the Scheygias, a remarkable race of a very dark-brown or rather black complexion, but not negroes. Until recently this people enjoyed complete independence, and defended their liberty against the army of the viceroy of Egypt, under his son Ismael Pasha, with heroic courage; but being overpowered by numbers and discipline, they were almost extirpated. The Scheygias speak the Arabic, and are probably of mixed origin. They are divided into three classes or castes; that of the learned, who have books and schools; that of the warriors, who are horsemen, each armed with a double-pointed spear, a sword, and a shield; and that of the merchants, who carry on a considerable traffic in exchanging native products for such foreign articles as they require. In their country, which borders upon that of the Berbers, are first met with the pyramidal monuments which adorned the ancient Meroë; the name of which has still been preserved in that of their chief place *Merawé*, though the ancient capital so called must be sought for farther to the south. With regard to the Berbers, they call themselves Arabians, that they may not be confounded with the negroes; but, from Burckhardt's description, there can be little doubt that they belong to the Nubian race.[1]

Above these regions, beyond the Astaboras or Tacazze, especially in Shendy, and thence along the Nile to Sennaar, the Arabic prevails; and the mass of the inhabitants may therefore be regarded as of Arabian descent, though with an intermixture of other blood. These places have always been, and still are, great resorts of trade; and this trade has ever been principally in the hands of Arabians, whose language, accordingly, extends as far as the confines of Abyssinia, where the Amhara and other dialects first begin to be spoken. But the Arabic is much less general among the scattered races wandering between the valley of the Nile and the Arabian Gulf; that is, among the Blemmyes, the Megabari, the Troglodytæ, and the Ichthyophagi, the tribes noticed by the ancient writers as occupying or roving through these parts. The principal race, however, is that to which Bruce and Niebuhr have given the name of Bischarries, the same who are called Bejas or Bedjas by the early writers. That this tribe is the same as the ancient Blemmyes has been very satisfactorily demonstrated by M. Quatremère. They occupy the same territory; their habits have in no respect changed; they are an aboriginal people, with nothing of the Arab about them; and consequently they belong to the class of nations comprehended under the general name of Berbers. The seat of the Bischarries begins in the north, where that of the Ababdés, extending from Cosseir to about the 23d degree of north latitude, terminates, and is principally a mountain ridge, which, rising close to the territory of the Ababdés, runs along the eastern coast of Africa to the neighbourhood of Suakin. This chain has from the earliest times been the abode of tribes who dwell in holes and caves originally formed by nature, but fashioned and improved by the inhabitants themselves, who have therefore been comprehended under the name of Troglodytes, or dwellers in caves. The Troglodytes of Ethiopia, according to Agatharcides, were herdsmen, with separate chiefs, or heads of tribes, amongst whom there existed a community of women, the result probably of their manner of life. During the rainy season they retired with their herds into the caves, where they lived upon clotted milk and blood; but as soon as the weather became favourable, they hastened with their cattle into the valleys, which afforded them pasturage, and which were often a subject of violent contention. Burckhardt gives nearly a similar description of these mountaineers, whom he represents as a very savage people, living entirely upon flesh and milk, and eating much of the former raw.[2] Some of these tribes spread themselves over the plains of Atbara, between the lower Tacazze and the mountains; but the peculiarities of the climate, particularly the overflowing of this branch of the Nile, which inundates the neighbouring plains, compels them to undertake a yearly migration in search of fresh pasturage. Another cause of their migrations, mentioned by Bruce, is the insect described by him under the name of the gadfly, which, from the commencement of the rainy season, abounds on the rich lands adjoining the Astaboras, and kills the cattle, if they are not immediately driven off to the higher sandy regions, whither the destructive insect does not follow them.

The southern part of the territory of Taka or Atbara, which is covered with thick forests, and overrun with savage beasts, as lions, panthers, elephants, and rhinoceroses, forms the seat of the hunting tribes, of whom a very accurate description has been given by Agatharcides. They dwell on the banks of the Astaboras, which separates them from Meroë; in other words, they are the Shangallas of Bruce. But no modern traveller has yet visited the interior of the district inhabited by this people. Bruce journeyed along its southern, and Burckhardt along its north-

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[1] "The people of Berber," says he, "are a very handsome race. The native colour seems to be dark-red brown. Their features are not at all those of the negro, the face being oval, the nose often perfectly Grecian; the upper lip, however, is generally somewhat thicker than is considered beautiful, though it is still far from the negro lip. They are tall and thin, even more so than the Egyptians, and very healthy, sick persons being scarcely ever found among them." (*Travels in Nubia*, p. 216, 233.)

[2] "The Bischarries, who rarely descend from their mountains, are a very savage people. Their only cattle are camels and sheep, and they live entirely upon flesh and milk, eating much of the former raw. According to the relation of several Nubians, they are very fond of the hot blood of slaughtered sheep; but their great luxury is said to be the raw marrow of camels. Their language is different from the Arabic, and approaches the Abyssinian. They are divided into four tribes, which are often at war with one another for the possession of the pasturages. Their women are handsomely formed, with very fine eyes and teeth, and are of a frank disposition. They are a genuine aboriginal people of Africa."

Ethiopian Nations.

ern boundaries, in his route through Taka to Suakin: its forests, its wild beasts, and its still wilder inhabitants, render it inaccessible. The habits of these tribes have remained the same for two thousand years; they are still the same rude savages described by Agatharcides. The Hylophagæ dwell under the branches of trees, which they fix in the earth in order to make themselves tents; the Dobenatis, the most powerful race of the Shangallas, live upon elephants and rhinoceroses, the flesh of which they preserve by drying it in the sun; the Baasa subsist upon the flesh of lions, and even that of snakes, which are found of an enormous size; and farther to the south is a tribe who, during the summer, feed on locusts, which they preserve by first roasting and then drying them. In the extreme east dwell the Struthiophagi, or ostrich-eaters, who must inhabit plains where alone ostriches are to be found. Lastly, we have here a new proof of the great influence which the natural circumstances of country and climate exercise upon the destiny of the human race. The various tribes of Shangallas still remain hunters, and completely savage, because their soil is unfit either for agriculture or pasturage; whilst the Bischarries follow a pastoral life, because their mountains afford food for flocks and herds. Where nature compels men to follow a nomadic life, it is vain to expect even an approach towards civilization.

But there yet remains to be noticed an Ethiopian nation, highly celebrated in antiquity, and copiously described by Herodotus; we mean the Macrobians. For the place which they have obtained in history this people are indebted to the expedition which Cambyses, from motives of cupidity, directed against them. A rumour of the vast quantity of gold possessed by them determined the Persian conqueror of Egypt to undertake this expedition; but before engaging in the enterprise, he sent from the city of Elephantis in Upper Egypt some Ichthyophagi, who understood their language, as spies into their country, and furnished the latter with presents for the king of the Macrobians, consisting of a purple robe, a golden necklace, bracelets, perfumes, and a cask of palm wine. The report of the spies, whose real vocation did not escape the penetration of this people, was, upon the whole, favourable. The Macrobians were, according to them, a tall and handsome race of men, who had their own laws and institutions, and elected the tallest amongst them as their king. They were not unacquainted with the use of wine; their food consisted of boiled flesh and milk; and, according to the account of their king, they were remarkable for longevity. Their country abounded in gold, which was the metal in common use among them, even for the fetters of their prisoners; their sepulchres were made of glass (ὕαλος); and their dead, after being embowelled, as in Egypt, were covered over with plaster, and then placed in cases, upon which were painted portraits of the deceased. Lastly, in return for the presents of Cambyses, the prince of the Macrobians sent him a bow, desiring the envoys at the same time to inform their master, that when he could bend it as easily as a Persian bow, he might undertake his projected expedition. These particulars are curious, as showing that the Macrobians must have been a nation living under fixed laws and institutions; that they understood the working in metals; that they inhabited the richest gold country of Africa; that their usages were in some respects akin to those of the Egyptians; and that they had made some progress in the cultivation of at least one of the fine arts. It appears, however, that they were ignorant of agriculture, as they knew nothing of bread except by report. But our rules of judging will not always apply to the African nations, who, proceeding from different points, and advancing in different directions, must necessarily arrive at a different end from that attained by Europeans.

Much diversity of opinion has prevailed as to the part of Africa which was occupied by this people. Bruce supposes the Macrobians to have been a tribe of Shangallas, who dwelt in the lower parts of the gold countries, Cuba and Nuba, on both sides of the Nile, to the north of Fazukla; an opinion which he founds on the slight circumstance that this race are in the habit, by means of ferules of hides, of rendering their bows nearly inflexible, like that sent in defiance to Cambyses. But as none of the Shangalla tribes have attained that degree of civilization attributed to the Macrobians, Heeren thinks that their abode must be sought for in another and more southern region; and that, in fact, it can only be determined by the statement of Herodotus that it lay on the Indian Sea, and abounded in gold, which it either produced or imported. We are thus carried to some seaport beyond the Arabian Gulf, although we may not be able to say with certainty which; but a district is nevertheless spoken of where agriculture was not in use, and its inhabitants lived, not on bread, but on flesh; and this, Heeren, proceeding on the account given by Cosmas, surnamed the Indian, of a remarkable trade carried on with the rich gold country on the confines of the land of frankincense, conceives, on very probable grounds, to have been situated on some part of the coast between Babelmandel and Guardefui. The land of African frankincense, according to Bruce, begins at Babelmandel, and stretches eastward almost to Cape Guardefui, taking in part of Adel or Zeyla. But as the land of frankincense adjoined Sasu, which is mentioned by Cosmas as a country very rich in gold mines, and as Sasu was situated near the sea, it may be concluded that the latter formed part of the coast, and also comprehended one or more ports at which the trade was carried on. The distance of Axum[1] from the land of frankincense, stated by Cosmas at fifty days' journey, agrees very well with this conjecture, which, moreover, is confirmed by the accounts modern travellers have given of that part of the African coast stretching from Babelmandel to Guardefui, and which is inhabited by a race neither completely negroes nor Arabians. The Samaulies, who are the people here alluded to, are not savages, but a friendly, well-disposed race, engaged in commerce, which they carry on between Africa and Arabia. Gums, myrrh, and frankincense, cattle and slaves, are the commodities exported by them, in exchange for which, as well as for gold and ivory, they receive the productions of Arabia and India, particularly the latter. The profits of this trade are very great; and the commerce, if it were not checked by the exorbitant customs imposed by the native rulers, would be immense. Taking the narration of Cosmas, therefore, in conjunction with the circumstances stated by Herodotus, it does seem probable that the Macrobians of the latter should be sought for in this region, that is, on some part of the coast not far from Cape Guardefui; and if the particulars mentioned by the former be applied to the same people, then every material difficulty vanishes, and the whole appears in a natural and satisfactory light.[2]

The Ichthyophagi derive their name from their food, which consisted of fish; and, besides the tribes in Africa, some also on the coasts of Persia and Arabia received the same appellation for the same reason. The African Ichthyophagi belong properly to the Troglodytæ, or dwellers in caves, and are only distinguished from others of this class by their food and manner of life. It is a remark which the whole history of the human race confirms, that the nations or tribes which subsist on fish are the very lowest in the scale of civilization; and the wretched savages we have mentioned form no exception to the truth of the observation. Strangers to all domestic ties; with no dwellings excepting clefts and holes; and without even fishing implements, as they fed only on those fish which were left behind by the retiring floods, they seem to have been of all savages at once the most miserable and the most degraded. Such being their character and condition, it seems difficult to conceive how Cambyses came to choose from such a race, individuals to act as envoys or spies. But as he sent for the Ichthyophagi from Elephantis in Upper Egypt, where a party of them must consequently have lived, and as his choice was no doubt determined by their acquaintance with the country and language of the Ethiopians, it is probable that they belonged to the roving tribes, who carried on the trade between Egypt and Ethiopia, and formed the caravans which travelled from the one country to the other. There was in fact no other way of passing from Egypt to the country of the Macrobians but by a caravan; and these people, as they understood the language spoken in the latter, must have journeyed thither once or oftener. Heeren intimates a conjecture that they belonged to the Ababdés, whose country stretches to the neighbourhood of the region above described, and who, from the most remote times, have been carriers of merchandize.[1]

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[1] The capital of Ethiopia.

[2] See Lord Valentia's *Travels*, vol. ii. p. 370–378. The vast quantity of gold is easily accounted for; it was either a natural product of the country, or the inhabitants had accumulated it by commerce; and hence the presents of the Persian king, consisting partly of golden ornaments, seemed to this people a mockery, which their prince was justified in taking as an insult, and returning by defiance.

The Ethiopian nations with which we have thus become acquainted must obviously be ranked, as a whole, in the lowest grade of civilization. Yet there still exists an evident difference of improvement among them; in fact, various gradations are observable, from the complete savage, whose rank might be disputed by the ourang-outang, to the hunting and fishing tribes, and from these again to the nomadic herdsmen of the mountains and the plains. But we do not anywhere discover a single nation which had united in a settled abode, and formed itself into a great and well-organized state. The nature of the country, and the climate, seem to have opposed a barrier which, in modern times at least, has not been overcome. Anciently, however, there did exist a better cultivated, and to a certain degree civilized Ethiopian people, who dwelt in cities, erected temples and other edifices, which they inscribed with hieroglyphics, lived under government and laws, and were famed over a considerable part of the earth for their progress in knowledge and the social arts. That state was Meroë.

Celebrated for upwards of two thousand years, Meroë, from its distant situation, has, until of late years, been involved in mystery and obscurity. But the hardy enterprises of Burckhardt and Caillaud, particularly the latter, have at length dispelled the dark cloud under which it was so long hidden; Meroë has at length been disclosed; and a new world of antiquities, the existence of which had not even been imagined, has been laid open, as it were, to our view. The southern boundary of Egypt had hitherto been considered as the utmost verge of ancient civilization and science. But more distant regions have at length been explored. Bruce and his predecessors led the way by crossing the Nubian desert, and others soon followed, who, penetrating the upper countries situated on the Nile, discovered that succession of monuments on its banks which has excited so much astonishment amongst antiquaries, as well by their number as their magnitude. Temple after temple appeared, some erected upon and others excavated in the rocks and the earth; scarcely was one passed when another appeared in view; colossal figures, buried up to their shoulders in sand, projected their enormous proportions; and an immense number of pyramids, with temples and ruins of cities close by or intermingled with them, rose to the sight of the astonished beholders. At last appeared the distant Meroë itself, with the ancient temple of Ammon still erect and majestic in its ruins.

The course of the Nile above Egypt, before its conflux with the Astaboras, lies through a valley enclosed on both sides by chains of hills, which sometimes recede and sometimes advance, until they almost approach the banks of the river. Any great deviation in the course of the stream is thus rendered impossible, though nothing exists to obstruct lesser windings in the wider portions of the enclosed valley. But as the soil of this valley was undoubtedly at one time as fertile in the upper regions as it is in Egypt itself (for where it could remain in that state it is still found so), we may conclude that it was at one time a highly cultivated country, with a numerous population, and a long succession of cities. As the mountain chains which enclose the valley are, however, succeeded on both sides of the river by sandy deserts,—on the east by the Nubian, and on the west by the great sandy waste which stretches right across Africa,—the sand has proved a still more formidable enemy here than in Egypt; and the lower chain affording but a slight defence, this deadly foe of all civilization has not only penetrated into the valley, but frequently buried, in part or in whole, the monuments which abound in it. The same cause must have occasioned some alterations in the course of the river itself, forcing separate branches into one channel, and joining small islands to the mainland. At all events, the valley of the Nile was certainly very different from what it is now, traces of old canals formed for extending its periodical overflow being everywhere visible; and these changes alone would have been sufficient to affect the condition of the inhabitants, even if other events had not conspired to accelerate the progress of decay. The river, deviating from its generally straight course, forms a bend or bow from 19° to 23° by running into the west, deeper into Libya; and the inner part of this incurvation is occupied by the Nubian desert. But the stream soon winds again to the eastward, and resumes a northerly direction, which it preserves throughout Nubia and Egypt.

For the first accounts of the course of the Nile above Egypt we are indebted to Herodotus, who collected them in Egypt, probably at Thebes or at Elephantis, beyond which he never proceeded. According to the information which he received, he states that, beyond the Egyptian boundary, the country becomes higher; that in this part a boat is dragged up the stream by means of a rope, fastened on either side, and if it chance to break, the boat is forced back by the violence of the current; that this navigation continues four days, the Nile winding, like the Meander, through a space of twelve schœni or seventy-two geographical miles; that the traveller next arrives at a plain where the Nile flows round an island named Tachompso; that the parts above Elephantis are inhabited by Ethiopians, excepting one half of the island, which is held by Egyptians; that close to the island is a vast lake,

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[1] Heeren, *Historical Researches into the Politics, Intercourse, and Trade of the Carthaginians, Ethiopians, and Egyptians*, vol. i. p. 388. English Translation. Oxford, 1832, 8vo.

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after crossing which the stream of the Nile, lost for a time in this expanse of water, is again met with; that a journey of forty days is then performed on the bank of the river; that in this part of the Nile sharp rocks rise above the water, and numerous shoals are met with, amongst which it is impossible to navigate; and that having passed through this country, the traveller again embarks in another boat, and, after twelve days' navigation, reaches an extensive city, the name of which is Meroë. Such is the statement of Herodotus, founded upon the information which he had collected in Egypt. In comparing it with the accounts of recent travellers, we shall find that all those objects, such as cliffs and rocks, which are not liable to change, still answer to his description; whilst, in other respects, supposing Herodotus to have been correctly informed, material alterations appear to have taken place.

Amongst the moderns, Norden was the first who attempted to navigate the Nile above Egypt, and to draw maps of its course. These, which reach only to Derri, Derar, or Deir, the end of his journey, are, notwithstanding all that has since been done, still the fullest in particulars. Burckhardt, in his first journey, kept near the banks of the river, and only penetrated as far as the frontiers of Dongola; in his second he traversed the Nubian desert. The journey and map of Legh extend no farther than the second cataract; and the magnificent work of Gau only reaches to the same place. The statements of Senkowsky, up to this limit, are also exceedingly accurate. Above the second cataract, from Wady-Halfa to the boundaries of Sennaar, or the ancient Meroë, Waddington and Hanbury have given a map of the course of the Nile; and for the more distant regions the authorities are Bruce, Burckhardt, and particularly Caillaud.

The winding course of the Nile above Syene is shown in Norden's twenty-fourth chart. The river here holds a serpentine course, but without any considerable curvature. Its current is so strong that Norden was obliged to quit his bark; Legh also found it difficult to make head against the stream; and, in the territory of Kalabsché, where it is confined within a channel about thirty yards in width, its impetuosity becomes so great as to render navigation exceedingly hazardous. As the voyage to the island of Tachompso is stated by Herodotus to be twelve schœni, or seventy-two geographical miles, which, navigating against the stream, it required four days to perform, this island may therefore be that now called Kalabsché, or another, named Ghyrshé, about twenty miles farther. The river contains many islands of which an accurate account is still wanting; but the great difficulty is the lake through which it is said to have flowed. The river, it is true, spreads out sometimes to a greater and sometimes to a less extent, but a lake is nowhere to be found. It follows, therefore, either that Herodotus was misinformed in regard to this particular, or that the features of the region in question have undergone a change, whether from the accumulation of sand, or from the gradual detrition of a natural barrier, which had originally dammed up the stream to a certain height, and formed the lake mentioned by him. We incline to the latter opinion, which is strengthened by what is known to have taken place at the cataracts; for, owing to the diminished obstruction, these rapids no longer answer the description of them given by the ancients. It may also be added, that, at the time of the annual floods, the Nile, in those parts where the mountain chains recede and suffer its waters to cover the valley, presents the appearance of a lake. From the site of the supposed lake the navigation of the stream continues unobstructed as far as the second cataract, near Wady-Halfa (21° 50′), a view of which is given by Gau; but above this cataract the bed of the river is often interrupted by rocky shoals, which cause rapids. Of these, one is near Wady-Attyr, another near Wady-Ambigo, and a third near Wady-Lamulé (under 21°); beyond which Burckhardt met with two others, the farthest being on the northern boundary of the kingdom of Dongola (19° 30′). But the obstruction of the navigation does not stop here; for Caillaud continues it as far as Merawé, where the great falls commence. Above the northern boundary of Dongola, the features of the country become much changed; the mountain chains recede much farther; and the Nile, hitherto frequently compressed into a narrow channel, here spreads out into many branches, enclosing a number of fruitful islands adorned with palm-groves, vineyards, and meadows covered with numerous herds, especially of camels. Every thing, says Hanbury, might here be found in abundance; nature has done her part, if man had performed his. But at this time the country appeared to great disadvantage, owing to the wanton devastation committed by the Egyptian army under Ismael Pasha. Having thus reached the immediate vicinity of the junction of the Astaboras or Tacazze with the Nile, or, in other words, the ancient island of Meroë, we shall, before entering the latter, pause for a little, to contemplate the monuments scattered along the Nubian portion of the valley of the Nile, the external features of which we have just described.

That the Nubian valley was once covered, on both sides of the river, with towns or villages, containing a numerous population, cannot possibly be doubted. Of these, Pliny has left us the names, and only the names, of twenty on each side. In his time they no longer existed, and it is probable that they were destroyed in the earlier contests between Egypt and Ethiopia. They must therefore have been very ancient; indeed the great population of the upper valley of the Nile favours the opinion which refers these towns to the time of the Pharaohs. But in Nubia, as in Egypt, the great works in architecture were confined to public edifices. The people during the day lived almost in the open air, and their dwellings were little more than resting-places for the night, or mere huts, which fell into decay as soon as they ceased to be occupied, and were speedily swept from the earth. Yet the ancient Parembole is still found in the present Debod; the name of Taphis is preserved in that of Tafa; Kalabsché is manifestly the ancient Talmis; Pselas is the present Dakké; Metacompso nominally survives in the modern Kobban; farther south Abrim represents the ancient Primis; and all these places are below the first Nubian cataract. But though the dwellings of man have vanished, not so those of the gods: the habitations of the former, like himself, have passed away; those of the latter seem to be imperishable. The series of temples commences on both sides of the Nile, almost immediately above the Egyptian cataracts. The first is that of Debod, twelve miles beyond Philæ (see article Egypt), on the left bank of the Nile; at nearly the same distance is that of Kardassy; and only five miles farther, that of Tafa. Next come the two temples of Kalabsché, one built upon the ground, the other hewn in the rocks; at about ten miles more is the temple of Dandour; and again, at a like distance, that of Ghyrshé, partly above ground, partly hewn out of a rock. Ten miles farther up is the temple of Dakké, at the same distance that of Maharraka, and sixteen miles farther that of Seboa, half built above, and half cut into the earth. Thirty miles farther stands the temple of Derar, on the right side; and sixty miles beyond this is the temple in the rocks of Ipsambul, with its colossi, forty-eight miles below the Nubian cataract of Wady-Halfa, near to which stands another temple. Beyond this the chain is broken, and does not recommence till about a hundred and fifty miles farther up, below the island of Sai, where there is a large temple; and thirty miles onward appears the temple of Soleb, which Burckhardt considers as the most southern of those constructed in the Egyptian style. Here, in fact, the first chain obviously terminates; but a new one also commences on the frontiers of the ancient Meroë; and about two hundred miles farther, near Merawé and the adjoining mountain of Berkal, temples re-appear, accompanied with groups of pyramids. About two hundred and forty miles onward we reach the junction of the Nile and Astaboras, crossing which we enter the island of Meroë, and, proceeding about ninety miles farther, arrive at the temples and pyramidal ruins of the ancient city of Meroë.

It would be inconsistent with the object of this article to attempt any general description of the monuments which we have just enumerated; this may be introduced with greater propriety under another head. But an attentive examination of these monuments suggests some general observations both as to their character and the history of the country where they are found, which we shall endeavour to state as briefly as possible. And, *first*, it appears that the religion, rites, and arts of Egypt, were not confined to its proper territory, but extended to the upper valley of the Nile, where the same deities were worshipped, and the rites of Ammon everywhere predominated, together with those of his temple-kindred and companions. *Secondly*, the character of the architecture, between which and the ornaments it received from the hand of the sculptor a distinction must be made, is upon the whole the same; but there is a progress in it which cannot be mistaken. In the monuments of Egypt, the art is found in its greatest perfection, perhaps also in its decline; here, however, we observe it in its rise and progress, from small grottos, such as those of Derar, until it attained the sublime magnitude in which it exists at Ipsambul. *Thirdly*, as the science of architecture appears to have commenced with grottos and tombs, and to have been perfected by degrees, the rock-monuments probably determined its principal character to the colossal form which it assumed. From the grottos it first rose into the open air; and then quitting this junction, erected monuments unconnected with such excavations. *Fourthly*, in regard to the sculptures and bas-reliefs with which the walls and columns of these monuments, below ground as well as above, are profusely ornamented, it would seem that, in general, they are not coeval with the edifices on which they are found. In the architecture, and even in the colossal statues, a progress may be traced from the first rude attempts to a state of comparative perfection: but in the reliefs nothing of the kind is discernible; all of these exhibit, in nearly an equal degree, the most improved state of the art; and the subject-matter of the inscriptions shows that the decoration of the walls and columns was posterior in date to the erection of the monuments. On every part of the temples of Ipsambul, Kalabsché, Derar, Ghyrshé, and Seboa, may be read in hieroglyphics the name of Rhamses the Great, or Sesostris, one of whose first military undertakings was an expedition against Ethiopia. *Fifthly*, the conclusion of Heeren, that these pictorial representations are not to be considered as mere ornaments or fanciful creations of art, but as historical records, is supported by every thing that has yet been discovered on the subject. And, *lastly*, as it appears that the Nubian monuments, strictly so called, are more ancient than those of Egypt, and that the course of improvement has, in general, followed that of the stream, it is highly probable that the latter country, whatever ascendency it may have acquired when its people had become a powerful nation, originally derived from the upper valley of the Nile the elements both of art and civilization.

But where, it may be asked, is the renowned Meroë to be found? This is the question which now demands our attention; and, without entering into the details of the inquiry, we shall state the results which Heeren has deduced from the statements of ancient writers, compared with and corrected by the accounts of modern travellers. The island of Meroë, then, is the present province of Atbar, situated between the river of the same name, otherwise called the Tacazze, on the right, and the Bahr-el-Abiad and Nile on the left. The point where the island commences is at the junction of the Tacazze and Nile; it is enclosed on the south by a branch of the above-mentioned river, the Waldubba, and a branch of the Nile, called the Bahad, the sources of which are nearly in the same district; it is situated between 13° and 18° of north latitude; and in recent times it has formed part of the kingdom of Sennaar, whilst the southern portion belongs to Abyssinia. Meroë was therefore an extensive district, surrounded by rivers, and in superficial content exceeded that of Sicily by rather more than one half. In the strict sense of the term it cannot be called an island, because it is not completely enclosed by rivers; but it was taken for such because the various rivers which flow round it were all considered as branches of the Nile; and, moreover, in the rainy season, it becomes a complete island by the overflowing of the rivers. Upon this island stood the ancient city of the same name, a little below the present Shendy, under 17° north latitude, and 5° 30′ east longitude. Its situation has been determined with the nicest accuracy; and its ruins, which Bruce and Burckhardt only saw at a distance, and hastily, confirm the deduction made from the testimony of the ancients. These, which have been carefully examined by later travellers, and placed before our eyes by their drawings, are very extensive, not being confined to a single spot, but found in a number of places; indeed the whole strip of land from Shendy to Gherri teems with them, and may therefore be considered as classic ground. The monuments still remaining consist of temples and pyramids, all private dwellings having long ago been destroyed. To the east of Assur is what Heeren denominates the great churchyard of pyramids, about eighty in number. They are divided into three groups, of which the most northern includes the largest and best preserved. They appear small compared with those of Middle Egypt, but they are more wonderful on account of their number. They are built of granite, but do not seem so massive in the interior as the Egyptian pyramids. It has not been ascertained whether sarcophagi and mummies are to be found within these monuments, or whether they are to be regarded as exclusively sepulchral structures. The antiquities to the south of Shendy consist of temples, in which Meroë itself was not deficient; two, a larger and a smaller one, being laid down in the plan of Caillaud. In these monuments, as well as in those of Naga or Naka, to the south-east of Shendy, we discover the architecture which attained to such perfection in the great temples of Egypt; and also observe the worship of Ammon and his kindred or associate gods, differing in no material respect from that which is exhibited on the monuments of Upper Egypt. At the distance of two days' journey from the pyramids, in the neighbourhood of which stood the city of Meroë, is the Ammonium, or ancient temple of Jupiter Ammon, within whose labyrinthine passages and courts was contained the oracle of the king of the gods. This has been clearly and fully established by Heeren, from the information furnished by Caillaud, compared with the statements of the ancient writers. The rarity of sculpture and hieroglyphics on this monument is remarkable; no trace of Egyptian art has been discovered here; and the few figures on the pillars have nothing in common with it,

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though one of them has evidently the hair dressed in the broad Nubian fashion. Thus, then, has at length been ascertained beyond all doubt that remarkable spot which antiquity generally regarded as the cradle of the arts and sciences; where hieroglyphical writing was first discovered; and where temples and pyramids had been constructed, whilst Egypt still remained ignorant of their existence, and the land afterwards called that of the Pharaohs was unadorned with monuments. For a masterly account of the religion, government, and laws of Meroë, as well as illustrations of its history, the reader is referred to the *Researches* of Heeren, which we have here followed.

Meroë was the capital of a country which both the Hebrew and Greek writers describe as one of the richest upon earth, and which, besides being reputed the cradle of the arts and sciences, was, from the most remote ages, distinguished for its trade and commerce. The Phœnicians, and even the Jews, were acquainted with it; the Hebrew poets cite the names of its various cities and harbours, expatiating on the treasures which were imported from them; and no sooner had the Greeks obtained some knowledge of these regions, than they exhausted language in extolling their boundless riches. From the very earliest times a close connection appears to have subsisted between Egypt and Ethiopia. The Hebrew poets seldom mention the one without the other, and both are represented as commercial nations. When Isaiah celebrates the victories of Cyrus, their submission is spoken of as his most magnificent reward: "The trade of the Egyptians, and the merchandise of the Ethiopians, and of the tall men of Saba, will come over to thee and become thine own." When Jeremiah extols the great victory which Nebuchadnezzar obtained over Pharaoh-Necho near Carchemish, the Ethiopians are mentioned as allied to the Egyptians; and when Ezekiel threatens the downfal of Egypt, he unites it with the most distant Ethiopia. Every page of Egyptian history, indeed, exhibits proofs of the close intimacy which subsisted between these countries; and commerce appears to have formed the common tie which united them. Of this commerce Heeren has collected all the particulars which are to be gleaned from the ancient writers, sacred and profane, and illustrated their statements with his usual ability and erudition. The conclusions which he has deduced from his investigations are alike curious and important, and, resting upon grounds which cannot be shaken, may be received as demonstrated propositions. *First*, it appears that, in the earlier ages, a commercial intercourse existed between the countries of southern Asia and Africa, between India and Arabia, Ethiopia, Libya, and Egypt, which intercourse was founded upon their mutual necessities, and became the means by which the civilization of these people was promoted. *Secondly*, the principal seat of this national intercourse for Africa was Meroë; and its principal route is still pointed out by a chain of ruins, extending from the shores of the Indian Sea to the Mediterranean. Adule, Azab, and Axum, are links of this chain between Arabia Felix or Yemen, and Meroë; Thebes and Ammonium are those between Meroë, Egypt, and Carthage. *Thirdly*, the chief places of this trade were likewise establishments of the priest-caste, who, as a dominant race, had their principal seat at Meroë, whence they sent out colonies, which in their turn became builders of cities and temples, and likewise founders of states. Thus the first seats of commerce were also the first seats of civilization; exchange of merchandise led to exchange of ideas; religion readily interposed its sanction in behalf of commerce; and "by this mutual friction was first kindled the sacred flame of humanity."

On this subject the reader may consult Heeren, *Researches into the Politics, Intercourse, and Trade of the Carthaginians, Ethiopians, and Egyptians*, vol. ii. Engl. transl.; Herodotus, iv. 197, et seqq.; Lyon's *Narrative*, p. 108, 112; Quatremère, *Mémoires sur l'Egypte*, vol. ii.; Burckhardt's *Travels in Nubia*; Legh's *Narrative of a Journey in Egypt, and the Countries beyond the Cataracts*; Waddington and Hanbury's *Travels*; Agatharcides, *De Rubro Mari*, in *Geog. Min.* Hudson, i.; Bruce's *Travels*, iii. p. 69–72; Valentia's *Travels*, ii. p. 394; *Deutsche Monatschrift*, July 1799; Norden, *Voyage d'Egypte et de Nubie*, Paris, 1795; Gau, *Antiquités de Nubie*, Paris, 1824; Caillaud, *Voyage à Meroë, au Fleuve Blanc*, etc.; Belzoni, *Narrative of Operations in Egypt and Nubia*, p. 71, 73; Champollion, *Précis du Système Hiéroglyphique*, p. 241; *Nouvelles Annales des Voyages*, xiii. 416; *Europæische Blätter*, October, 1824; Eratosthenes *apud Strabo*; Heeren, *Researches on the Asiatic Nations*; Vincent's *Periplus of the Erythræan Sea*; Maillet, *Description de l'Egypte*, p. 197, 216, etc.; Alvarez, *Viaggio della Etiopia*; Mannert, *Geography of the Greeks and Romans*; Salt, *Voyage to Abyssinia*; St John, *Egypt and Mohammed Ali, or Travels in the Valley of the Nile*, London, 1834, in 2 vols. 8vo. (A.)

ETHNARCHA, ETHNARCH (formed of εθνος, *nation*, and *αρχη*, *command*), a governor or ruler of a nation.

There are some medals of Herod surnamed the *Great*, on one side of which is found Ἡρωδου, and on the other Εθναρχου, or *Herod the Ethnarch*. After the battle of Philippi, Antony passed into Syria, constituted Herod and Phasael his brother tetrarchs, in which quality he committed to them the administration of the affairs of Judæa. Herod therefore had the government of the province before the Parthians entered Syria, or before the invasion of Antigonus, which did not happen till six or seven years after Herod commanded in Galilee. Herod was, therefore, truly ethnarch, for he cannot be otherwise denominated; so that it must have been during that period the medals were struck which gave him this title; and these medals are a confirmation of what we read in history of the government which that prince was intrusted with before he was raised to royal state. Josephus gives Herod the appellation of *tetrarch* instead of that of *ethnarch*; but the two terms come so near to each other, that it is easy to confound them together. Though Herod the Great left by will to Archelaus all Judæa, Samaria, and Idumea, yet Josephus tells us he was then only called *ethnarch*.

ETHNOPHRONES, in *Antiquity*, a sect of heretics in the seventh century, who made a profession of Christianity, but joined thereto all the ceremonies and follies of Paganism, such as judicial astrology, sortileges, auguries, and other divinations.

ETIENNE, ST, an arrondissement of the department of the Loire, in France, extending over 450 square miles. It is divided into nine cantons and seventy-six communes, and contains 107,506 inhabitants. The capital is the city of the same name, situated on the river Furand. It is a large manufacturing place for silk ribbons and other silk goods, and also for ironmongery, as well as for muskets, pistols, swords, and other weapons. It contains 16,295 inhabitants. In the neighbourhood is abundance of fossil coal. Long. 4. 15. E. Lat. 45. 22. N.

ETIQUETTE, a French term, primarily denoting a ticket or title affixed to a bag or bundle of papers, and expressing its contents. It is also used, when applied to the Spanish and some other courts, to signify a particular account of what takes place daily in the king's household, and of the chief ceremonies which are there observed. It likewise denotes those forms which regulate the decorum of conduct towards persons of various ranks and stations.

ETOILE, a town of the department of the Drome, in

France, where good wine is produced. It contains 2314 inhabitants.

ETNA, or Ætna, a volcano in Sicily. See Ætna.

ETOLIA, a country of ancient Greece. On the east it was separated by the river Evenus, now the Fidari, from the Locrenses Ozolæ, and on the west from Acarnania by the Achelous; on the north it bordered on the country of the Dorians and part of Epirus, and on the south it extended to the Bay of Corinth.

The Etolians were a restless and turbulent people, seldom at peace amongst themselves, and ever at war with their neighbours; strangers to friendship or the principles of honour; and ready to betray those who trusted them, upon the least prospect of reaping any advantage from their treachery; in short, they were looked upon by the other states of Greece as but little better than outlaws and public robbers. On the other hand, they were bold and enterprising in war, inured to labour and hardships, undaunted in the greatest dangers, and jealous defenders of their liberties, for which they were, on all occasions, willing to hazard their lives, and to sacrifice all that was most dear to them. They distinguished themselves above all the other nations of Greece in opposing the ambitious designs of the Macedonian princes, who, after having reduced most of the other states, were forced to grant them a peace upon honourable terms. The constitution of the Etolian republic was copied from that of the Achæans, and constructed with a view to form, as it were, a counter alliance; for the Etolians bore an irreconcilable hatred to the Achæans, and had conceived no small jealousy of the growing power of that state. The Cleomenic war, and that of the allies, called the Social War, were kindled by the Etolians in the heart of the Peloponnesus, with no other view than to humble their antagonists the Achæans. In the latter contest, this people, with the assistance only of the Eleans and Lacedæmonians, held out for the space of three years against the united forces of Achaia and Macedonia; but they were at last obliged to purchase a peace, by ceding to Philip the whole of Acarnania. As they parted with this province much against their will, however, they watched all opportunities of wresting it out of the Macedonian's hands; and with this view they entered into an alliance with Rome, which proved of great service to the Romans in their war with Philip; but growing insolent on account of their services, they soon made war upon their allies, by whom they were overcome, and only obtained a peace upon severe conditions. After the conquest of Macedonia by Paulus Æmilius, they were reduced to a much worse condition; for not only those amongst them who had openly declared for Perseus, but such as were suspected of having favoured him in their hearts, were sent to Rome, in order to clear themselves before the senate; and there they were detained, and never afterwards suffered to return to their native country. Five hundred and fifty of the chief men of the nation were barbarously assassinated by the partizans of Rome, for no other crime than that of being suspected of wishing well to Perseus. The Etolians appeared before Paulus Æmilius in mourning habits, and made loud complaints of this inhuman treatment; but they obtained no redress; and ten commissioners, who had been sent by the senate to settle the affairs of Greece, decreed that those who were killed had suffered justly, since it appeared that they had favoured the Macedonian party. From this time the chief honours and employments in the Etolian republic were only conferred upon those who were known to prefer the interest of Rome to that of their country; and as such persons were alone countenanced of Rome, all the magistrates of Etolia became the creatures and mere tools of the Roman senate. In this state of servile subjection they continued until the destruction of Corinth and the dissolution of the Achæan league, when Etolia, with the other free states of Greece, was reduced to the condition of a Roman province, and called the province of Achaia. Nevertheless, each state and city was governed by its own laws, under the superintendence of the prætor whom Rome sent annually into Achaia: the whole nation paid a certain tribute; and the rich were forbidden to possess lands anywhere except in their own country.

In this state Etolia continued, with little alteration, under the emperors, till the reign of Constantine the Great, who, in his new partition of the provinces of the empire, divided the western parts of Greece from the other, calling them *New Epirus*, and subjecting the whole country to the *præfectus prætorii* for Illyricum. Under the successors of Constantine, Greece was parcelled out into several principalities, especially after the taking of Constantinople by the western princes. At that time Theodorus Angelus, a noble Grecian, of the imperial family, seized on Etolia and Epirus, the former of which he left to Michael his son, who maintained it against Michael Palæologus, the first emperor of the Greeks, after the expulsion of the Latins. Charles, the last prince of this family, having died without issue in 1430, bequeathed Etolia to his brother's son, also named Charles, and Acarnania to his natural sons Memnon, Turnus, and Hercules; but great disputes having arisen about this division, Amurath II. after the reduction of Thessalonica, laid hold of the favourable opportunity thus offered, and in 1432 drove them all out. But the Mahommedans were afterwards dispossessed of this country by George Castriot, prince of Epirus; who, with a small army, opposed the whole power of the Ottoman empire, and defeated the Turks in twenty-two pitched battles. That hero, at his death, left the greater part of Etolia to the Venetians; but the latter not being able to make head against the Ottoman power, the whole country was soon reduced by Mahommed II.

ETON, or Eaton, a town situated on the left bank of the Thames, and connected with Windsor by a bridge. It is situated in the hundred of Stoke, in the county of Buckingham. The chief object of attraction is the well-endowed college, the most celebrated for the classical scholars it has produced of any institution in the kingdom. It was founded by Henry VI. in 1440, and the foundation scholars, chosen for their proficiency, are transferred to King's College, Cambridge, of which they are admitted to fellowships as vacancies arise. The buildings are in the Gothic style, well adapted for the accommodation of the provost, masters, and scholars; but those of the latter not on the foundation are boarded and lodged at houses in the town. The number of scholars is about 300. The town depends on the college, has no market, but is supplied from that of Windsor adjoining. The population amounted in 1801 to 2026, in 1811 to 2279, in 1821 to 2475, and 1831 to 3232.

ETRURIA, an ancient province or country of Italy, bounded on the north by Liguria, from which it was separated by the river Macra, now Magra; on the side of Cisalpine Gaul, by the lofty ridges of the Apennines; on the east by Umbria, from which it was separated by the river Tiber; and on the west by the Tuscan Sea. The country thus situated appears to have been one of the earliest seats of European civilization, and the principal source whence Rome derived her laws, customs, and superstitions.

ETRUSCANS, or Tuscans, called by the Greeks *Tyrrhenians* or *Tyrsenians*, and by themselves *Rasena*, were the people who inhabited ancient Etruria, and who, at a period when the rest of Europe was immerged in ignorance and barbarism, had attained to a high degree of civil and social refinement.

Etruscans.

The origin of this interesting race, from whom have descended some monuments of the earliest humanity, appears to have puzzled the ancients as much as it has perplexed the moderns; and, notwithstanding all that has been written on the subject, particularly by the Italian antiquaries, it is still beset with difficulties and involved in obscurity. The question chiefly agitated amongst the ancients was whether the Etruscans were Pelasgi from Greece, Lydians from Asia Minor, or an indigenous and aboriginal race in Italy; and the moderns have added more than an equal number to the hypotheses of the ancients. Herodotus represents them as a colony of Lydians, who, having been compelled by famine to emigrate from Asia, arrived, after various wanderings, in Umbria, where they settled and called themselves Tyrrhenians, from Tyrrhenus, son of their king Atys, the conductor of the emigration. This tradition, whencesoever derived, has been almost implicitly followed by the ancient writers; indeed Cicero, Strabo, Velleius Paterculus, Seneca, Pliny, and Plutarch, all agree in repeating the assertion that the Etruscans originally came from Lydia.

But the moderns have not in general evinced the same deference for the authority of Herodotus in this particular, and have advanced a variety of hypotheses, some of them, perhaps, not much more tenable nor better founded than the story told by the father of history. Dempster, who may be said to have laid the foundation of an accurate knowledge of Etruscan history and antiquities, is of opinion that there existed an original nucleus of inhabitants in Etruria, which was successively augmented by the Lydian immigration, and by Pelasgic colonies from Thessaly and Arcadia. Bochart coincides pretty nearly with Dempster, but maintains that there must have existed a direct intercourse between the Etruscans and Phœnicians, as many of the fables, superstitions, customs, and monuments of the former were, according to him, of oriental origin. Winckelman and the Count de Caylus, admitting an ancient communication with the East by means of the Mediterranean, substitute Egypt for Phœnicia; and to the supposed intercourse between Etruria and the land of the Pharaohs the former ascribes the remarkable progress made by the Etruscans in the sciences and liberal arts; whilst the latter is of opinion that this people borrowed every thing from Egypt, and that the origin of science and art in Etruria is coeval with the commencement of their commercial connection with that country. Improving upon these views, some writers have advanced a step further, and maintained that the Etruscans not merely carried on an intercourse with Egypt, but were actually of Egyptian descent, in fact a colony or branch of the great nation established in the Delta and valley of the Nile. This opinion has been adopted by Buonarotti, Gorius, Mazzochi, Maffei, Guarnacci, and Lord Monboddo; but it has been strenuously opposed by a number of the most learned Italian, French, and German archæologists, particularly by Bardetti, Pelloutier, Fréret, Funccius, Adelung, and Heyne, who, though differing from one another in some points, have generally contended for the northern and Celtic origin of the Etruscans. Lanzi, without pretending to investigate the origin of this remarkable people (who, he nevertheless seems to think, were Lydians, augmented at different times by the accession of Pelasgic tribes), endeavours to prove that, whatever may have been their descent, the language, religion, learning, and arts of the Etruscans, were of Greek origin; that the period of their greatest perfection in the arts of design was posterior to the subjugation of Etruria by the Romans, when the intercourse with Greece had rendered them familiar with the beautiful models of that country; and that, even admitting all languages to have been originally derived from the East, and many Greek words to have sprung from Hebrew or Phœnician roots, still there exist in the Etruscan such evident traces of Hellenic descent, particularly in the names of gods and heroes, as to render it almost impossible to derive their origin from any other source. Further, in support of this theory, the learned Italian attempts to show from the inscriptions on the Eugubine tables, that the Etruscan was Æolic Greek, without either the monosyllabic characteristics of the northern dialects, or the prefixes and affixes peculiar to most of the oriental languages. Humboldt, again, supposes this people to have been a connecting link between the Iberians and Latins, or a sort of transplanted offset from the great Celtic stem. But the learned and ingenious Müller adopts an intermediate opinion. Admitting a primitive population of Etruria, as to whose origin he does not venture to decide, he conceives that there are nevertheless grounds for assuming that they became intermingled with Pelasgic colonists from the coast of Lydia, where the latter had for a time settled, and acquired the name which they afterwards rendered notorious by their piracies in the Ægean Sea. It would be hopeless to endeavour to reconcile these conflicting hypotheses, and endless to examine their respective merits in detail.

Of all those, however, who have laboured to resolve this *quæstio vexata* in the archæology of history, Niebuhr has, we think, been, upon the whole, the most successful. The origin of the erroneous opinions as to the extraction of the Etruscans, he traces to two assumptions, which he shows to be equally fallacious: first, that the Pelasgians could only be derived from Greece, a supposition which probably gave rise to the story of the migration from Thessaly; and, secondly, that because the Mæonians were Tyrrhenians, these Tyrrhenians, like those of Lemnos, were of the same stock with the ancient inhabitants of Agylla and Tarquinii, whence arose the story of the Lydian emigration of the ancient Tyrrhenians, as told by Herodotus. But, on the authority of Xanthus, Dionysius proves that the account of Herodotus was not founded upon a Lydian tradition; and, from the complete difference of the two nations in language, usages, and religion, he justly contends that it would deserve no credit, even if there had been a tradition to the effect stated. He asserts that the Etruscans spoke a language which bore no affinity to any other known form of speech; and this assertion would deserve full credit, even if we had only the evidence of Dionysius, inasmuch as Etruscan was then, and for a considerable time afterwards, a living language, in which, as we gather from Lucretius,[1] books were written and read. It is further confirmed by the inscriptions still extant, in which every resource of etymology has failed to detect any analogy between the Etruscan and the Greek language or the kindred branch of the Latin; and these singular monuments, which have thus resisted the utmost efforts of modern scholarship and ingenuity, will to all appearance remain for ever a dead treasure, unless a key shall accidentally be furnished for their interpretation, by the discovery of a bilingual inscription. In opposition to the unanimous evidence of the ancients, who distinguish the Etruscan from the Sabine and Oscan, it has indeed been maintained that all the nations of Italy, remains of whose language occur in inscriptions, spoke only dialects of the same radical form of speech; but this opinion, which has chiefly prevailed amongst the Italian scholars, is at variance with the results of unbiassed investigation; and it appears to have been completely established that the Etruscan language, being wholly original and peculiar, bore as little affinity to the Sabine and Oscan as to the Latin and Greek, with which fanciful etymologists have vainly sought to connect it.[1]

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[1] Non Tyrrhena retro volventem carmina frustra
Indicia occultæ Divûm percurrere mentis.

The Etruscans, during the most prosperous period of their history, inhabited Etruria proper, and the country about the Po, besides distant colonies. The Rætians and other Alpine tribes were also of Etruscan origin; and so were the Lepontians and Camunians, perhaps also the Euganeans, who inhabited Venetia before the founding of Patavium. It has been suggested by Niebuhr that the language spoken by the people of Groeden in the Tyrol, a language which seems to stand alone in its peculiar roots, may have some claims to be considered as a relic of the ancient Etruscan.[2] The Brenner formed the northern boundary of the Rætians, and consequently of the Etruscan race, who in the time of their greatness had probably occupied the mountains as a bulwark against irruptions from the north. Some, however, are of opinion that Rætia was the original home whence the Etruscan people issued, and spread first in Upper Italy, and afterwards across the Apennines; and the harshness of the Etruscan language, which seems still to survive in the Florentine pronunciation, has been adduced as an argument for the Alpine origin of the people.

In the ancient history of the Umbrians it was related that the Etruscans had conquered three hundred towns of their nation. The Umbrians, therefore, must have once occupied the greater part of the countries, including Tuscany, which the Etruscans possessed in the zenith of their power. According to the tradition of the Lydian migration, Pisa, and the whole country to the rocky summits of the Alps, were wrested from the Umbrians by the Tyrrhenians; and Pliny considers the Umbrians as the ancient inhabitants of Etruria who were expelled by the Pelasgians. Without entering into the question whether Cortona was Etruscan or not, still Cære, Graviscæ, Alsium, and Saturnia, were certainly occupied by the Etruscans as conquerors, after expelling the people called in Italy Siculians, and in Greece Pelasgians and Tyrrhenians. The Pelasgians were also in possession of Tarquinii before the Etruscans; Populonia was called a colony of the Volaterrans, who had driven the Corsicans from the coast; and Pisa is mentioned by Dionysius amongst the places which the Etruscans had wrested from the Pelasgians. But all statements, however probable or well attested, were at length forced to give way to the story of a Lydian extraction, which of necessity placed the first settlement of the immigrants on the lower sea, and thus involved the whole question in perplexity. What the native annals of the Etruscans related as to their origin we know only negatively; in them the Lydian legend which has created so much embarrassment had no place.[3] According to this view, then, there appear to have been two consecutive conquests: that of the Umbrians by the Pelasgians; and that of the Pelasgians by the Etruscans, who, as it were, absorbed all the others, and ultimately became the dominant people. The principal stock of the nation, however, seems to have been formed out of that great Pelasgian race which at one time extended from the rivers Po and Arno in Italy to the Phyndacus in Asia, but which, even when intermingled by conquest with other tribes, never succeeded in spreading itself over the whole of Northern Italy. The Etruscans, indeed, at no period of their history possessed the whole of Cisalpine Gaul. On the westward their territory extended only to the Ticinus, where dwelt the Ligurians, who were afterwards driven back by the Gauls; and the land to the south of the Po was also either occupied by the latter, or rendered uninhabitable by swamps. When the Gauls made their irruption the Umbrians were still masters of the country now called Romagna; but between the Veneti and the Gauls, Etruscan settlements maintained themselves until the time of the Romans.

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[1] The names of Tuscan and Etruscans were as foreign to this people as that of Tyrrhenians. They called themselves *Rasena*, as already stated; and the other appellations applied to them were evidently arbitrary, accidental, or hypothetical. The ancient Roman terms were *Etruria* for the country, and *Tusci* for the people; that of *Etruscus* did not come into use till after Cato's time, though subsequently it became the more usual in the language of books. But the old name must have continued prevalent in the mouth of the people; for under the later emperors the name of *Tuscia*, which had never before been used in writing, was applied to the country, and in the middle ages passed into *Toscana*, whence *Toscani*. (Niebuhr, *History of Rome*, p. 90, Cambridge, 1828.) Professor Müller thus sums up his researches into the origin of the Etruscans: "It remains that we regard the Tuscan nation as an original and peculiar people of Italy; their language is widely different from the Greek; the names of their gods are not those which we find among the earliest Greeks, whom we call Pelasgi, and which passed from them to the Hellenes; there is much too in the doctrine of their priests entirely foreign to the Greek theology. But it appears to have been the fate of this nation, which never displayed any independent civilization, but only adopted that of the Greeks, to have been indebted for its first impulse towards improvement to a Greek, or at best half Greek tribe. The Tuscans themselves, in their native legends, referred their polity and civilization to the maritime town of Tarquinii and the hero Tarchon, both probably only variations of the Tyrrheni. Here it was that the much-dreaded Pelasgians of Lydia landed and settled, bringing with them the arts which they had acquired at home, or on their way. For the first time, the barbarous land saw men covered with brass array themselves for battle to the sound of the trumpet; here first they heard the loud sound of the Lydo-Phrygian flute accompanying the sacrifice, and perhaps witnessed for the first time the rapid course of the fifty-oared ship. As the legend, in its propagation from mouth to mouth, swells beyond all bounds, the whole glory of the Tuscan name, even that which did not properly belong to the colonists, attached itself to the name of Tarchon, the disciple of Tages, as the author of a new and better era in the history of Etruria. The neighbouring Umbrians and Latins named the nation, which from this time began to increase and diffuse itself, not from the primitive inhabitants, but from these new settlers. For since, in the Eugubine tables, *Turste* occurs along with *Tuscom* and *Tuscer*, it is impossible not to conclude, that from the root TUR have been formed Tursicus, Turscus, Tuscus; as from the root OP, Opscus and Oscus; so that Τυῤῥηνοι, or Τυρσηνοί, and Tusci, are only the Asiatic and Italian forms of one and the same name." (*Die Etrusker*, vol. i. p. 100.)

[2] Hormayr, *Geschichte von Tyrol*, p. 139. This suggestion is eminently deserving of attention and verification. For as the Etruscan alphabet is known, the determination of a few roots would serve as a fulcrum, by means of which the great lever of tentative interpretation might be applied.

[3] "It is evident," says a late writer, "that the Etruscans themselves believed that they sprung from the Lydians, and that they *inculcated this belief on others*" (Dunlop, *Hist. of Rom. Literature*, vol. ii. p. 7); and he grounds this assertion on a circumstance mentioned by Tacitus (*Annal.* lib. iv. c. 55). Eleven cities of Asia contended, it would appear, for the infamous honour of erecting an altar to Tiberius; and this ridiculous and humiliating question was argued in presence of the tyrant, before that degraded senate whom he had publicly taunted with their abject servility. On this occasion the Sardians, one of the contending parties, insisted on their affinity to the Etruscans; in proof of which they produced a decree of that people, repeating the tale told by Herodotus, and of course attesting the original confraternity of the Sardians with the ancient inhabitants of Etruria. This is the statement of Tacitus. What degree of credit may be due to a document founded upon a vague tradition, flattering to popular vanity, produced in such a cause before such judges, and as to the authenticity of which the historian is silent, our readers will not, perhaps, find it difficult to determine. The only thing surprising is, that in such a competition of servility and adulation, a grave historian should have sought for materials to support an hypothesis, improbable in itself, and at variance with the best authorities on the subject.

This people appear to have had twelve cities to the north of the Apennines, and an equal number to the south of that range. Amongst the former, of which we can give but a very indistinct account, may be classed Verona, which is denominated a Rætian city by Pliny, and Mantua, which is called Tuscan both by him and by Virgil. Hatria, Melpum, and Felsina were also included in the twelve cities north of the Apennines. Hatria, once a place of great commerce, gave its name to the upper sea; Melpum, to the north of the Po, was destroyed by the Boii, Senones, and Insubres, on the same day that Camillus took Veii (in the year of Rome 358); and Bononia, under the name of Felsina, was once the capital of Etruria. The twelve cities south of the Apennines, which were leagued together as the chief places of their respective districts, are nowhere enumerated by name; but Livy incidentally mentions eight of them, namely, Cære, Tarquinii, Populonia, Volaterra, Arretium, Perusia, Clusium, and Rusellæ, as having contributed to forward Scipio's preparations. Cortona was also accounted one of the chief places in Etruria, and both Veii and Vulsinii were probably included in the original number. But whether Capena, or Cossa, or Fæsulæ, completed the twelve, it is now impossible to decide. The changes produced by time and by conquest have involved this part of the subject in impenetrable obscurity.

The territory belonging to each of these capitals had several provincial towns, some of them dependent colonies, and others inhabited by subjects, the descendants of the old population who had been subdued. But as the Etruscan state was founded on conquest, the government naturally assumed the character of an aristocratical oligarchy. It was not by popular assemblies, nor even by the deliberations of a numerous senate, but by meetings of the chiefs or magnates of the land (*principes Etruriæ*), that the general affairs of the nation were decided on. The assemblies held at the temple of Voltumna were of this exclusive kind, and hence in no degree corresponded with the institutions of really free nations, such as the Latins and the Samnites. These Etrurian chiefs were the persons from whom the Roman youth received instruction in the sacred sciences of divination; they were at once a warlike and sacerdotal caste, the Lucumones whose ancestors had committed to writing the revelations of Tages. But they were patricians, not kings, as has been commonly supposed. Lucumo of Clusium, Lucumo who succoured Romulus, and Lucumo who removed from Tarquinii to Rome, were only powerful men in their respective cities; the Cilnii and Cæcinæ were Lucumones in Etruria, just as the Claudii and Valerii were patricians in Rome, and were not less noble in birth than the latter, though, as Romans, reckoned only amongst the commons. But these ruling houses were exposed to the violent revolutions which everywhere threaten an oligarchy, even in the midst of its own body, when it is not upheld by some powerful protection from without. The chiefs expelled each other by force of arms, or were driven into exile by the combinations of intrigue; and it was in the spirit of these feuds for the refugees to be restored by the dangerous mediation of the common enemy, the Romans. Even so late as the second Punic war, the government of the Etruscan cities remained exclusively vested in the senators, or nobility; the latter were, what Louis XIV. called himself, the state; and, when a ferment began in Etruria, it was entirely suppressed by securing the submission of the senate at Arretium. The people, who had no political existence as such, were out of the question. A free and respectable commonalty was never formed amongst the Etruscans; on the contrary, the species of feudal system, anciently established by conquest, was obstinately maintained and extended; the mass of the population were mere serfs; and hence arose the remarkable weakness of the great Etruscan cities in their contests with Rome, when the victory was to be determined by a numerous, brave, and steady infantry. National impotence ever follows the degradation of the people. What the Etruscans might have been if, some centuries earlier, they had had a country, is evinced by the effect of the Roman franchise conferred upon them at the conclusion of Sylla's war. In this contest the part taken by the chiefs was taken by all; and every free man, however excluded or restricted by the old but now expiring constitutions of his own country, obtained the privileges of Roman citizenship; nor was the boon either undeserved or misapplied.

The regal office, which was not hereditary in a single family, as in Greece, but elective for life, as at Rome, continued at Veii until its fall. At Arretium, however, the king may perhaps have been chosen from amongst the Cilnii, a family of high distinction. The twelve federal cities nominated a common high priest, who presided at the national festivals. In common enterprises the supreme command was generally committed to one of the twelve Lucumones, who received a lictor from each city. Even Porsenna, highly as he is celebrated in the old legends, is in Roman history only king or chief of Clusium; yet he had influence sufficient to set the whole power of the nation in action. In like manner all the twelve cities paid homage to Lucumo Tarquin; and in the earlier times a closer union seems occasionally to have been effected by the power of a supreme chief, as Mezentius or Cœles Vibenna. But such union appears to have been the exception rather than the rule, and to have depended on accident rather than on organization; nor have we been able to discover satisfactory evidence of the existence of a distinct federal constitution, such as some writers have rather gratuitously imagined. Yet loose as was the federal bond in Etruria, it seems to have had the effect of preventing wars between the cities, of which no trace is to be found in history. Such, then, being the nature of their association, it is probable that the islands subject to the Etruscans were not under the dominion of the whole nation, but under that of the adjacent maritime cities; and, accordingly, it seems as if the Cærites stood alone when, leagued with the Carthaginians, they attacked the Phocæans of Alalia, which happened in the year of Rome 220. The principal insular dependency of the Etruscan states was Corsica, which paid them a tribute; but it is not improbable that they had also settlements in the island of Sardinia.

The maritime cities of Etruria having early engaged in navigation, were stigmatised and hated on account of the piracies they committed in the western seas, which, anterior to the founding of the Grecian colonies in Sicily, were thus rendered impassable to peaceful navigators. Niebuhr is, however, inclined to think that this reproach may have applied chiefly to the Pelasgian Tyrrhenians, whom the Etruscans afterwards subdued; and indeed all the corsairs of the lower sea seem to have been considered by the Greeks as Tyrrhenians. But without entering into any details respecting their nautical adventures, whether piratical or other, it may be observed, that navigation naturally implies an interchange of commodities; and a fruitful land, rich in internal treasures, supplied abundant materials for the commercial spirit in Etruria. From a very early period the Etruscan maritime cities appear to have engaged in commerce; and in the time of Aristotle, treaties, by which the rights of trade were respectively determined and secured, subsisted between these cities and Carthage. Amongst the subjects of this commerce may be mentioned the produce of the iron mines of Elba,[1] and of others upon the mainland of Etruria, which yielded a more abundant supply of a purer kind of metal than any in the ancient world. The same island also furnished copper for their coinage, and for those works in brass or bronze in which they so greatly excelled. Müller supposes them to have also traded in amber, which substance, he thinks, they received by an inland route, extending from the shores of the Adriatic to those of the Baltic; but as his chief reason for this supposition appears to be, that, in Pliny's time, amber was conveyed by the same route into Italy, and as no safe conclusion can be drawn respecting the extent of early communications, from those which are found established at a later period, when circumstances had wholly changed, the conjecture in question must, we suspect, be dismissed as untenable. On the subject of Etruscan commerce, however, the information which has reached us is too scanty and imperfect to enable us to deduce any distinct conclusions, either as to the extent to which it was carried on, or the particular channels in which it flowed.

The works constructed by the Etruscans still astonish us even in their ruins, and could scarcely have been executed in small states without taskmasters and bondsmen. The everlasting monuments of Egypt are the products of the direst tyranny acting remorselessly upon the most abject slavery. But the scarcely less durable works of the Etruscans differ from those in the valley of the Nile, in having all of them been directed towards some great object of public utility. Labour was not uselessly or wantonly expended in the erection of pyramids, obelisks, and temples, to gratify the inordinate vanity of despots, or to extend the empire of superstition; if the people suffered in the hard service imposed on them, it was not for vain or idle purposes; they were employed by their rulers on whatever seemed best calculated to promote the defence or augment the wealth of the nation at large. The walls of their cities, constructed of huge blocks of polygonal stones, still ubsist in imperishable solidity, where pains have not been aken to demolish them; the theatre at Fiesole, and a colossal building near it, are on a scale of equal grandeur; and other monuments might be mentioned which have been constructed in the same Cyclopean style. The ich valley of the Arno, anciently a lake and a swamp, was drained by means of a cut through Mount Gonfalina, which blocked up the valley, but which, by means of this operation, was made to afford a passage for the stream owards Pisa; the arms, too, by which the Po discharges tself, were also excavated or directed by the Etruscans; nd its Delta was likewise the fruit of their labours. Anther useful art practised by this people consisted in leting off, by means of tunnels, lakes which had been formed in the craters of extinct volcanoes. In the territory of Perugia there are traces of many such lakes, which have een completely dried up, by means of the tunnels, which, hough now unknown and never cleared out, still drain off he water as before.

The renown which belongs to a nation that excelled in he arts has become as it were the inheritance of the Etruscans. But from the peculiar constitution of government and society in ancient Etruria, it has been conjecured, not without appearance of reason, that the works in ronze and clay, and the bas-reliefs, attributed to them, were the produce, not of the dominant race, but of their subject bondsmen or serfs; and that in reality the Etruscans, properly so called, were as little given to the arts as the Romans by whom in their turn they were subdued. The striking difference observable between Tarquinii and Arretium in their works of art, seems to correspond with the different origin of the earlier inhabitants of northern and southern Etruria. Volaterra was naturally led, by the stone quarries in its neighbourhood, to engage in the works for which it became celebrated. The two former cities, however, wrought only or chiefly in clay. Arretium made red vases, with elegant figures in relief, in a style altogether peculiar. Those of Tarquinii were painted, and both in colour and design resemble some discovered near Corinth, of which Dodwell has given engravings. Painted vases are found only in the district of Tarquinii, and where they occur those of Arretium are never met with; besides, they differ from the Campanian in all those peculiarities for which the Greek works of the same kind are distinguished. The resemblance which is thus found to exist between the vases of Tarquinii and of Corinth irresistibly reminds us of the story of Demaratus, who is said to have been accompanied by the potters Euchir and Eugrammus; a circumstance evidently designed to express that Tarquinii derived from Greece her skill in handling clay, and the elegant drawing with which her vases were adorned. The earliest Etruscan statues were of clay; but the statues belonging to the first ages of Rome were almost uniformly of bronze, and the master-pieces which shed lustre on Etruscan art are all of the same material. That this art received its refinement from the Greeks cannot, we think, be reasonably questioned. Works of primitive antiquity attest its original rudeness; and to the Greeks alone, improving on Egyptian models by a close study of the finer forms and proportions of nature, belonged that skill which throws life and beauty into the delineation of the human figure. Hence the subjects of many of the most beautiful Etruscan works of art are obviously taken from the Greek mythology, which, in Etruria, was found as well adapted to the purposes of the artist as in the land to which it was native. But the Etruscans, when their taste had once been formed, treated their own conceptions in the spirit of their masters; and, though no doubt inferior in grace and delicacy of execution, they acquired a correctness in drawing which may almost be stated as a national characteristic. In the she-wolf of the Capitol we have an example of the perfection to which Etruscan art had attained about the middle of the fifth century of Rome; nor are the finest gems probably of a much more recent date.

As a national heroic story was wanting to Etruscan art, it sought for subjects in the Greek mythology; and the legends of Thebes and of Ilium must have been familiar to the people. The Greek poems were read in Etruria, and Greek legends, transfused into Etruscan, lived in the speech of the nation, or in compositions in the native tongue. Indeed the works of art are not unfrequently inscribed with the names of the Greek heroes, adapted to the forms of the Etruscan language, of which it is matter of regret that so little is yet known. Varro mentions Tuscan tragedies by one Volnius, who, it appears, lived not long before, and probably intended these as an experimental attempt to introduce a national drama. But be this as it may, the Grecian construction of the theatre at Fæsulæ is evidence that Greek dramas, either originals or translations, were performed there, as well as at Tusculum and Bovillæ in Latium; nor can it be doubted that this

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[1] Insula inexhaustis chalybum generosa metallis. (*Æn.* x. 174.)

Etruscans.

theatre is much earlier than the time of Sylla, since in size and magnificence it far surpasses the scale of a Roman military colony, which, besides, cannot be supposed to have had any taste for the exhibitions peculiar to such a place. The amphitheatre was the only place to which such colonists would have repaired for amusement. It is proper to add, however, that in Etruscan inscriptions we do not find any thing bearing the slightest resemblance to Greek rhythms, which could scarcely have been concealed even in an unintelligible language; and that the place whence the Fescennine musical dialogue received its name was a Faliscan, not an Etruscan town.

The music of the Romans was derived from Etruria, whence also they obtained their scenic or histrionic singers. This is the only branch of art in which the ancients attributed to the Etruscans the honour of invention; but here the invention related merely to the instrument; for we do not read of any mood or measure ascribed to the Etruscans. This instrument was the flute, which the Romans regarded as native to Etruria, though modern antiquarics pretend that it is to be considered as of Lydian origin, and even as a proof of the Lydian immigration mentioned by Herodotus. The celebrity which the Etruscans obtained in music, as well as in other accomplishments, was, no doubt, in part owing to their having been the neighbours of a rude and uncultivated people like the Romans, who naturally admired whatever was new or strange, and who, until they became acquainted with the Greeks, derived all that was ornamental in their system of public and private life from Etruria.

The literature of the Etruscans presents the singular phenomenon of an alphabet almost perfectly deciphered, with a language completely unintelligible. A combination so strange has led more than one writer to maintain that the language is Pelasgic or Æolic Greek, and to appeal in proof of this to the alphabet; but, unfortunately, there is a total want of connection between the premises and the conclusion; and the result of all the investigations yet instituted has been to disprove this notion. The Etruscan characters were formed like the Greek, from that one amongst the various Asiatic alphabets whence all the modes of writing in use throughout Europe appear to have been derived. That Etruria received them directly from the Phœnician would not certainly be proved by the direction of the writing from right to left; but when to this we add the omission of the short vowels, the practice of noting double consonants by a single letter, as in all the Aramaic systems of writing, and the want of the vowel O, which are peculiarities purely Punic, the presumption in favour of Phœnician origin is considerably increased. From this last circumstance, however, nothing can be decisively determined as to the pronunciation, inasmuch as the Semitic languages are not defective in the vowel, which is wanting to the Etruscan. The Phœnicians also distinguished numbers by letters; but not so the Etruscans. What we denominate the Roman numerals are of Etruscan origin, and occur frequently on their monuments, being probably the abbreviated remnants of a hieroglyphical art of writing in use before the alphabetical, and, like the Aztecan numerals, representing objects connected with particular numbers. Niebuhr thinks them indigenous to the west. But however this may be, the literal form which these numerals have now assumed cannot mislead any one as to their hieroglyphical origin. With respect to the Etruscan language, which remained harsh in sound and uncouth in its forms, all the labour which has hitherto been bestowed in attempting to interpret it, though valuable for its collateral results, has proved wholly fruitless in reference to its direct object. Lanzi, abandoning the oriental and northern etymology, endeavoured to explain the Etruscan from the Pelasgic; and for many years after the appearance of his Essay, his explanations were acquiesced in, and even made the basis of various etymological hypotheses. But when at length credulity gave place to inquiry and examination, it was perceived that his modes of proceeding were much too arbitrary; that he had produced no evidence of the existence of the words and forms which he had assumed to be Greek, in order to identify them with the Etruscan; and that other monuments, discovered since his time, could not in any way be explained by his system. In short, his interpretation was purely tentative and conjectural, without even accidental felicities of supposition; and hence, of all the Etruscan words, of which pretended explanations have been given, only two (AVIL RIL, *vixit annos*, or rather perhaps *ætatis annos*) seem to have been really interpreted. Professor Müller's observations on this subject are well deserving of attention, especially in reference to the expectations which appear to be entertained of the enlargement of our historical knowledge by the comparison of languages.

"We might give much ampler satisfaction," says he, "if, after Lanzi's method, we sought in the monuments of the Etruscan language for single sounds resembling the Greek and Latin, and, persuaded that similar sounds must have a similar meaning, endeavoured to explain all that could not be brought to agree, by an arbitrary prothesis, epenthesis, paragoge, and similar cheap expedients. Without blaming the learned Italian, in whose time the most eminent literati had very confused ideas of the formation of language, we may maintain that his leading principle (that analogy is the character only of cultivated languages, and that the ruder any language is, the greater liberty might be taken in the use of it) is entirely false. This may justify us for having paid so little regard to etymologies, which, as they are arbitrary in themselves, suppose an arbitrary character in the language to which they are applied. If we use only genuine monuments, and require a certain evidence for every explanation of a root or a grammatical form, our apparent knowledge of the Etruscan language shrinks almost to nothing....... It is not probable that the application of the still existing remains of the languages of the north and north-west of Europe should have those beneficial results for our knowledge of Etruscan which some appear to anticipate. The Germans and Celts are originally divided in a very marked manner, by their locality, from the nations of the Mediterranean; they only gradually approach these and come into collision with them; and even though the languages of both nations may belong to that great family which from time immemorial has diffused itself throughout Europe and Asia, yet they have distinct peculiarities, which we have no reason to believe are found in those of Italy. One fundamental and indelible characteristic of the Celtic languages seems to be, that they mark grammatical forms by aspiration and other changes of the initial consonants; a thing not practised in any other European language, but found in all the branches of the Celtic, as the Welsh, Cornish, Gaelic, Irish, and *Bas Bréton*. This mutability of the consonants is a circumstance which must be perceptible even in a small number of written remains, and which could not well have escaped us had the Etruscan been Celtic. The Iberian family, once widely diffused on the shores of the Mediterranean, may have dwelt in close vicinity to the Etruscans; but the remains of its language in the Basque are completely different from the rest of Europe; and its grammar shows so little affinity with what we know of the Etruscan, as to afford very slight support to the opinion of the affinity of the two nations. What may have been the relation of the Tuscan to the extinct Ligurian, or to the language of those Alpine tribes whose names alone are preserved in history, is a question respecting which we have not even a glimmering of knowledge."[1]

Any attempt indeed to interpret the Etruscan, without the aid of bilingual inscriptions, such as those on the Rosetta stone and obelisk of Philæ, which afforded a key to the Egyptian phonetic hieroglyphics, will be pure loss of labour. The discovery of such monuments, however, is, in regard to time and manner, an incalculable event; but still it is within the range of probable calculation; and the age which has witnessed the interpretation of Egyptian hieroglyphics by means of such aids should not hastily despair of any thing. If a translation were discovered, not in Latin or Greek, but in Oscan or even Umbrian, the latter have so much affinity to the Latin, that much might be learned from such a version for the explanation of the Etruscan. We repeat, however, that without the aid of bilingual inscriptions, the language of ancient Etruria is likely to remain as great a mystery as the inscriptions of Persepolis, or the arrow-headed legends contained on bricks found amidst the ruins of Babylon.

Of the early history of Etruria we can only collect a few detached facts of little importance, which are to be gleaned from Livy, and from short notices in the Greek historians and poets; and must ever deplore the loss of the works of Aristotle and Theophrastus on the civil institutions of the Tyrrheni, as well as regret that the history of the Emperor Claudius has disappeared. We find this people engaged in a contest with Tarquinius Priscus (about 610 B. C.), but obliged to acknowledge at least a nominal dependence on the power of Rome. They joined the Carthaginians in an attack on the Phocæans, who having left Asia Minor (about 547 B. C.) to escape the persecutions of Cyrus the elder, had settled in Corsica, and threatened to dispute with them the supremacy of the western seas. For the next two centuries they appear to have enjoyed tranquillity; until, roused to exertion by the ever encroaching spirit of the Romans, they determined to make an united effort to check the power of their dangerous neighbours. The hostile forces met (309 B. C.) near Lake Vadimon, which is still to be seen on the east of Etruria, near the Tiber, below the modern village of Bassano; and the result was, as usual, favourable to the cause of Roman supremacy. The Tuscans were completely defeated; and from this moment were compelled to co-operate in extending and strengthening the power of the conqueror. They now became incorporated with the Roman people, and can no longer be considered as a separate nation.

For a detailed account of this people, see Micali *L'Italia avanti il dominio dei Romani*, Milan, 1825, with *Antiqui Monumenti per servire all' Opera intitolato* L'ITALĪA, &c., Firenze, 1821; *L'Italie avant la Domination des Romains*, with historical notes and illustrations by M. Raoul-Rochette, Paris, 1824, in 4 tomes; Niebuhr's *Roman History*, English trans., Cambridge, 1828, in 2 vols.; Müller, *Die Etrusker, vier bucher*, Breslau, 1828; Inghirami, *Monumenti Etruschi, o di Etrusco nome*, 1821–1825, in 6 vols. 4to; Heyné, *Etrusca Antiqua*, Nov. Soc. Götting. 1766; and Gori, *Museum Etruscum*. For the ancient language of Etruria, see Dempster, *De Ætruria Regali*, Florence, 1723, in 2 vols. fol.; Lanzi, *Saggio di Lingua Etrusca, e di altre Antiche d'Italia*, 1789, in 3 vols. 8vo; and Müller, *Die Etrusker*, above referred to. (A.)

ETSCH, a circle in the Austrian province of Tyrol, which extends over 1400 square miles, comprehending three cities, three market-towns, 310 villages, 12,094 houses, and 99,782 inhabitants. The chief place is Botzen.

ETTLINGEN, a city, the capital of a bailiwick of the same name, in the duchy of Baden, in Germany. It contains 398 houses, and 3429 inhabitants, employed in cotton manufactures, and in making paper, oil, and gunpowder.

ETTMULLER, MICHEL, an eminent physician, was born at Leipsic, on the 26th of May 1644. After having studied the learned languages, the mathematics, and philosophy, first in his native town, and afterwards at Wittenberg, he returned to Leipsic, and, having devoted himself wholly to medicine, obtained the degree of bachelor in 1663, and a license or diploma in 1666. But being desirous to extend his acquirements, which were already considerable, he resolved, before taking his last degrees, to visit the countries most celebrated for the cultivation of the sciences; and with this view he commenced an interesting course of travels in Italy, sojourning for some time in the more remarkable cities of that fine country, as Naples, Rome, Florence, Bologna, Venice, Padua, Pisa, Pavia, Milan, and Turin. He then crossed the Alps and proceeded to Paris, where he remained seven months; after which he passed over into England, and thence repaired to Holland. His intention was to employ an entire winter in attending the prelections of learned professors in the university of Leyden; but his design in this respect was thwarted by his sudden recall to Leipsic, where, on the 20th of August 1668, two days after his arrival, he received the degree of doctor, a distinction which proved the forerunner of new dignities. The Academy of the Curious in Nature admitted the young doctor one of its members in 1670, and the Faculty of Medicine in 1676. About the same time the university of Leipsic confided to him the chair of botany, and appointed him extraordinary professor of surgery; offices the duties of which he discharged with distinction. But he did not long enjoy his preferment; for, on the 9th of March 1683, he was suddenly cut off, in consequence of a hectic fever, occasioned, as some say, by a chemical experiment. Although Ettmuller only wrote short dissertations and mere *opuscula*, he nevertheless enjoyed an immense reputation. His feeblest productions were reprinted, translated, and commented on; nor were his lectures, collected by numerous auditors, sometimes with much inaccuracy, less favourably received by the public. He had the art of interesting and fixing the attention by a ready elocution, and by arguments much more specious than solid. Of this any one may satisfy himself by the perusal of his works, of which the following is a list: 1. *De Singularibus*, a thesis defended by Ettmuller in 1663; 2. *Medicina Hippocratis Chimica*, Leipsic, 1670, in 4to; 3. *Vis Opii diaphoretica*, Leipsic, 1679, in 4to; 4. *Chimia Rationalis ac Experimentalis curiosa*, Leyden, 1684, in 4to; 5. *Medicus Theoria et Praxi generali instructus*, Francfort and Leipsic, 1685, in 4to; 6. *Opera Omnia theoretica ac practica*, Lyons, 1685, in 4to; 7. *Opera Omnia; nempe Institutiones Medicinæ cum Notis, etc.* Francfort, 1688, in fol.; 8. *Opera Medica theoretico-practica*, Francfort, 1676, 2 vols. fol.; 9. *Operum Omnium Medico-physicorum editio novissima*, Lyons, 1690, 2 vols. fol.; 10. *Opera Omnia in Compendium redacta*, London, 1701, and Amsterdam, 1702, in 8vo. But of all the editions, the best is that which the son of the author published under the title of *Opera Medica theoretico-practica per filium Michaelem Ernestum, etc.* Francfort, 1708, in 3 vols. fol. There is no complete translation of the works of Ettmuller, but there are numerous German, English, and French translations of the different treatises.

Michel Ernest Ettmuller, son of the preceding, born at Leipsic in 1673, was also a physician of some eminence.

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[1] *Die Etrusker*, vol. i. p. 64, *et seq.*

Besides collecting and editing the works of his father, which formed the principal labour of his life, he wrote a number of theses and memoirs, which are not destitute of merit, and died on the 25th September 1732. (A.)

ETYMOLOGY, that branch of grammar which explains the origin and derivation of words, and which has for its object to arrive at their primary signification; for which reason Quintilian calls it *originatio*. The word is formed from the Greek, ετυμος, *verus*, true, and λεγω, *dico*, I speak; and hence Cicero calls etymology *notatio* and *veriloquium;* though Quintilian chooses rather to denominate it *originatio*.

A judicious inquiry into etymologies is thought by some to be of considerable use, because nations who value themselves for their antiquity have always looked upon the antiquity of their language as one of the best titles they could plead; and the etymologists, by seeking the true and original reason of the notions and ideas attached to each word and expression, may often furnish an argument of antiquity, from the remaining traces thereof, compared with the ancient uses. Add to this, that etymologies are necessary for the thorough understanding of a language. For, to explain a term precisely, there seems a necessity for recurring to its original import, in order justly and satisfactorily to explain its meaning in its secondary applications. The force and extent of a word is best conceived when a person knows its origin and etymology.

It is objected, however, that etymology is in some measure arbitrary, and built altogether on conjectures and appearances; and the etymologists are charged with deriving their words from whatever source they please. Nor indeed is it an easy matter to go back into the ancient British and Gaulish ages, and to follow, as it were, by the tract, the various imperceptible alterations which a language has undergone from age to age; and as these alterations have sometimes been merely owing to caprice, it is easy to assume a mere fancy or conjecture as a regular analogy; so that the public may easily be prejudiced against a science which seems to stand on so precarious a footing. It must be owned, however, that etymologies are frequently so far fetched as sometimes to render it impossible to perceive any resemblance or correspondence between roots which are alleged to be identical. Quintilian has shown that the ancient etymologists, notwithstanding all their learning, adopted very ridiculous derivations.

EUBAGES, an order of priests or philosophers among the ancient Celtæ or Gauls. According to some, the Eubages were the same with the Druids and Saronidæ of Diodorus; but others maintain that they were the same with what Strabo calls Evates.

EUBŒA, a long narrow island, now called *Negropont*, which stretched along the east coast of Greece from the Sinus Maliacus, to nearly the most southern point of Attica. Its length was 1200 stadia according to Strabo, 150 miles according to Pliny, but its greatest breadth is nowhere more than 150 stadia, or eighteen miles and a half. High and rocky mountains rendered the eastern coast unfit for habitation, but on the side opposite the mainland, where the ground became more level, there were several good harbours, and in ancient times cities of no inconsiderable importance. The island produced corn in sufficient quantities to serve as the granary of Athens. It possessed warm baths, iron mines in the vicinity of Chalcis, and salt, which Pliny considered as equal in purity to that of Attica. The mountains furnished wood in large quantities; but as the fir was liable to rot, it was of little use for ship-building.

Its inhabitants were composed of several distinct races. In the south dwelt the Abantes, mentioned by Homer; and in the north were the Histiæi, who had probably passed over from Thessaly, where we find a district of that name. The Leleges and Dryopes are also said to have occupied a part of the island.

The attack of the Persians must have tended considerably to weaken the strength and power of its inhabitants. Eretria, one of its most flourishing cities, paid the penalty of having assisted its compatriots the Ionians, by being razed to the ground, and its people carried off to the remote regions of Asia. Before the period of the Peloponnesian war it seems to have been wholly subject to the sway of Athens, but towards the conclusion of the contest it succeeded in recovering its independence. The Eubœans, however, do not appear to have gained much by this change; for they became a prey to domestic feuds, and were at length glad to acknowledge their ancient dependence on Athens. They continued in this state till the Macedonians had succeeded in annihilating the maritime supremacy of the Athenians, when the principal cities of Eubœa were garrisoned by the troops of Macedon. The Romans once more restored it to freedom. (Thucyd. i. 114, viii. 5; Diodor. xv. xvi.; Liv. xxxiv. 51; Strab. x. 444.; Plin. iv. 12.) For a more full description, the reader may consult Mannert, *Geographie des Griechenlandes*, Leips. 1822 (vol. viii. p. 244). See NEGROPONT.

EUCHARIST, the sacrament of the Lord's supper. The word in the original Greek, Ευχαριστια, literally imports *thanksgiving;* being formed from ευ, *bene*, well, and χαρις, *gratia*, thanks. This sacrament was instituted by Christ himself; and the participation of it is called *communion*.

As to the manner of celebrating the eucharist among the ancient Christians; after the customary oblations were made, the deacon brought water to the bishops and presbyters, standing round the table, to wash their hands; according to the words of the psalmist, "I will wash my hands in innocence, and so will I compass thy altar, O Lord." Then the deacon cried aloud, "mutually embrace and kiss each other;" which being done, the whole congregation prayed for the universal peace and welfare of the church, for the tranquillity and repose of the world, for the prosperity of the age, for propitious weather, and for all ranks and degrees of men. After this followed the mutual salutations of the minister and people; and then the bishop or presbyter, having sanctified the elements by a solemn benediction, broke the bread, and handed it to the deacon, who delivered it to the communicants; and in like manner afterwards the cup. The sacramental wine was usually diluted or mixed with water. During the time of administration hymns and psalms were sung; and the whole concluded with prayer and thanksgiving, upon which the people saluted each other with the kiss of peace, and so the assembly broke up.

EUCHITES or EUCHITÆ, a sect of ancient heretics, who were first formed into a religious body towards the end of the fourth century, though their doctrine and discipline existed in Syria, Egypt, and other eastern countries, before the birth of Christ. They were so called because they prayed without ceasing, imagining that prayer alone was sufficient to save them. They rested chiefly on the injunction of St Paul, *Pray without ceasing.* The name is formed from the Greek, ευχη, *prayer*, whence ευχιται, the same with the Latin *precatores*. They were also called *Enthusiasts* and *Messalians*, terms denoting the same thing as Euchites.

EUCHOLOGIUM, Ευχολογιον, a Greek term, signifying literally *a discourse on prayer*. The word is formed form ευχη, *prayer*, and λογος, *discourse*. The euchologium is properly the Greek ritual, in which are prescribed the order and manner of every thing relating to the order and administration of their ceremonies, sacraments, ordinances, and the like. Gore has given an edition of the Greek euchologium in Greek and Latin, with notes.

EUCLID of Megara, a distinguished philosopher and logician, who flourished about 400 years before Christ. The Athenians having prohibited the Megareans from entering their city on pain of death, this philosopher disguised himself in women's clothes, in order to attend the lectures of Socrates. After the death of Socrates, Plato and other philosophers went to Euclid at Megara, in order to shelter themselves from the tyrants who then governed Athens. Euclid admitted but one chief good, which he sometimes called God, sometimes Spirit, and sometimes Providence.

Euclid of Alexandria, author of the most ancient elements of geometry which have come down to us, and for this reason justly regarded as one of the fathers of science. He has been sometimes confounded with Euclid of Megara, the disciple of Socrates, and the founder of a philosophic sect who pushed to an extreme the subtilties of dialectics. The place of his birth is unknown. But Proclus Diadochus, one of his commentators, informs us that he opened a school of mathematics in Alexandria in the reign of Ptolemy the son of Lagus; and Pappus extols his kindness and affection for those who laboured to advance the study of geometry. This being all that is known of the life and character of Euclid, it only remains therefore to speak of his works, some of which have been lost. Amongst those which we possess, however, the most remarkable is that which is simply entitled *Elements*, as if to indicate that it contained the entire body of principles upon which the pure mathematics then rested. This work now consists of fifteen books; but the last two are attributed to Hypsicles, a mathematician of Alexandria who flourished at a later period. Euclid, however, neither was nor could be the inventor of all that is contained in his work; for geometers more ancient than he, including Hippocrates of Chio, had written Elements; but, on the other hand, there can be little doubt that he added to the pre-existing stock of elementary truths, improved the demonstrations in which his predecessors had failed, and composed a whole which, by more severe forms of reasoning, and a more exact concatenation of propositions, superseded all works of the same description which had been previously written, and became the basis of instruction in the mathematics. These *Elements* were first commented on by Theon, and by Proclus; but whatever success such commentaries may have had in the school of Alexandria, they remained wholly unknown to the occidentals of the middle ages, who derived all their knowledge of geometry, such as it was, from the works of Boecius, and from a production entitled *De Principiis Geometriæ*, ascribed to St Augustin.[1] It was only in the twelfth and thirteen centuries that Athelard in England and Campano in Italy laboured to decipher and translate Euclid from the Arabic versions, including the commentary of the Persian geometer Nazir-Eddin, which was held in great estimation among the Saracens; for although there is reason to believe that Boecius had made a complete Latin translation of Euclid, it has not come down to our times; and, in fact, it was not till long after the revival of letters, and when versions had been multiplied by means of the press, that a part of the *Elements* of Euclid was introduced into the course of instruction in the schools. In order to form an idea of the entire work, however, it may be considered as composed of four parts. The first of these parts comprehends the first six books, and may be divided into three sections, viz. the demonstration of the properties of plane figures treated in an absolute manner, as in books first, second, third, and fourth; the theory of the proportions of quantities in general, which is the object of the fifth; and the application of this theory to plane figures, as in book sixth. The second part contains the seventh, eighth, and ninth books, which are denominated *arithmetical*, because they treat of the general properties of numbers. The third part consists only of the tenth book, in which the author considers in detail incommensurable quantities, and which he terminates by proving that the diagonal of a square and its side cannot have a common measure; a doctrine, we may add, which is much more ancient than Euclid, since Plato, towards the close of his seventh book of *Laws*, pronounces those who have no idea of such incommensurability as sunk in almost brutish ignorance. The fourth part, which is composed of the last five books, treats of planes and solids. But of all this great body of geometrical doctrine, the only portions which have been considered as adapted to the purposes of instruction are the first six books, together with the eleventh and the twelfth; the propositions which they contain having formed the basis of all the elements of geometry which, under whatever form, have from time to time been given to the world. The fifth book, however, has often been omitted in such publications, because the notation of our arithmetic, and still more that of our algebra, have greatly simplified the theory of proportions; and, for the same reason, the other arithmetical books, which it is now difficult to read, are justly considered as more curious than useful. But, in borrowing their materials from the work of Euclid, modern authors have frequently altered the arrangement; and on this subject there have arisen two contradictory opinions, which have been debated with very great warmth, yet still remain as irreconcilable as ever. The concatenation established by Euclid, and even the forms which he has employed in demonstrating his propositions, are regarded by some as almost the last term of perfection in works of this kind; whilst others, again, have considered these as mere essays, which, however excellent in themselves, leave room for the introduction of a more natural order and more simple demonstrations. Ramus, who declared war on the dialectics of Aristotle, accuses Euclid of omissions and redundancies, and expresses his conviction that it was with reference to these imperfections that Ptolemy inquired if there were not a more easy method than that usually employed for learning geometry; an inquiry which, as is well known, elicited from Euclid the reply, that in the mathematics there was no road for kings. Antony Arnauld, and the author of the Logic of Port-Royal, have also blamed the order followed by the Greek geometer, and disputed some of his definitions;[2] but if Arnauld, either from not being very profound in the mathematics, or by reason of the great difficulty of the subject, failed, as Ramus and so many others had done, in the changes which he attempted to introduce into the *Elements*, his reasons for making the attempt still remain in all their force. For, whatever may be said to the contrary, it is certain that they are deficient in that order which, causing the propositions, as far as possible, to arise out of one another, exhibits in full evidence the analogies which connect them, assists the memory, and prepares the mind for the investigation of truth. But whether, in the actual state of the science, it be practicable to reconcile this order with the rigour of demonstration, or to obviate objections the force of which, abstractedly considered, cannot be disputed, is a question which it would far exceed the limits of this notice to discuss.[1] If it be resolved affirmatively, which appears to us possible, then no reason would exist for giving an absolute preference to the *Elements* of Euclid. As a precious relic of antiquity, and as one of those works of science which time has thrown least in arrear of actual knowledge, the *Elements* would doubtless continue to be classed in the first rank of mathematical productions; but their too arbitrary arrangement, and the style in which they are written, sometimes too prolix and at other times too concise, would no longer constitute the essential character of the geometric or synthetic method, in opposition to the analysis of the moderns. The true difference of these two methods of treating the science of quantities consists in this, that the one is founded on the immediate consideration of the properties of figures, whilst the other employs arbitrary signs, combined by the operations of calculation. The first is geometry itself, not that of Euclid more than of any other; the second is an application of algebra, which ought not to be confounded with analysis, inasmuch as synthesis may be effected with algebraic signs as well as with the figures of geometry. The latter, however, which may also be treated analytically, presents operations equivalent to the resolution of certain equations. Of this some propositions contained in the book of *Data* are remarkable examples; propositions which, by a natural and certain path, lead to the solution of problems otherwise undiscoverable. The book of *Data* was particularly relished by Newton, who, persuaded that a proposition scarcely deserved to see the light unless it could be demonstrated without the assistance of calculation, conceived that a more profound study of this treatise would have enabled him to dispense with the aid of such an instrument. But it may well be doubted, to say nothing more, whether his successors, by pursuing a similar path, would have ever attained those great and striking results which they have derived from the new methods of calculation. Besides the *Elements* and the *Data*, which are the most important works of Euclid, Pappus and Proclus mention the following: *Introductio Harmonica*, *Sectio Canonis*, relating to music; *Phænomena*, containing an exposition of the appearances produced by the motion attributed to the celestial sphere, a work subjoined to the book *De Sphæra Mobili* of Autolycus; *Optica*, *Catoptrica*, concerning direct vision and mirrors; *Liber de Divisionibus*, treating of the divisions of polygons; and the lost works, entitled *Porismatum libri*, *Locorum ad superficiem libri*, *Fallaciarum liber*, and *Conicorum libri*. At the end of the works of Euclid is a short fragment, entitled *De Levi et Ponderoso*, the author of which is unknown; it is, however, of almost no value. The editions of the works of this geometer are so numerous that we cannot undertake to indicate all of them, and must therefore confine ourselves to the principal ones. Of the complete works there are, 1. *Euclidis Opera, Græce, cum Theonis expositione, cura Grynæi*, Bâle, 1530, in fol.; 2. *Euclidis quæ supersunt omnia, ex recensione Davidis Gregorii, Græce et Latine*, Oxford, 1703, in fol.; 3. *Les Œuvres d'Euclide, en Grec, en Latin, et en Français, d'après un Manuscrit très ancien, qui était resté inconnu jusqu'à nos jours*, par Peyrard, Paris, 1814, in 8vo. The manuscript here referred to was one of several sent from Rome by Monge, and supposed to date from the end of the ninth century; in it the *Data* are placed immediately after the thirteenth book, and thus separate from the rest of the work the fourteenth and fifteenth books, which are ascribed to Hypsicles. In 1533, Hervage published at Bâle, in folio, a complete edition of the *Elements*, in the Greek text, with the exposition of Theon, and the Commentaries of Proclus on the first book. The following are the principal Latin translations: 1. *Præclarissimum Opus Elementorum Euclidis perspicacissimi in artem Geometriæ*, the first publication of the *Elements* by means of printing, Venice, 1482; 2. *Euclidis Elementorum libri XV. una cum scholiis antiquis, a Frederico Commandino Urbinate in Latinum conversi, Commentariis quibusdam illustrati*, Pesaro, 1572, in fol.; 3. *Euclidis Elementorum libri XV. demonstrationibus accuratisque scholiis illustrati, auctore Christophoro Clavio*, 1574, in 8vo; 4. *Euclidis Elementorum libri XV. breviter demonstrati, opera I. Barrow*, London, 1678, in 8vo; 5. *Elementorum Euclidis libri XV. ad Græci contextûs fidem recensiti et ad usum tyronum accommodati, edente Baermann*, Leipsic, 1769, in 8vo; 6. *Euclide Megarense philosopho, solo introduttore delle scientie mathèmatiche diligentemente reassettato per Nicolo Tartaleo Brisciano.* This last, however, is rather a paraphrase than a translation. The following are editions which only contain part of the *Elements*: 1. *Analysis Geometrica sex librorum Euclidis a Christiano Herlino, una cum commentariis et scholiis perbrevibus in eosdem libros a Cunrado Dasypodio*, 1566, in fol.; 2. *Euclidis Elementorum libri priores sex, item undecimus et duodecimus*, Oxford, 1747, in 8vo; 3. *Euclidis Elementorum libri priores sex, etc. sublatis iis quibus olim hi libri a Theone aliisve vitiati sunt, et quibusdam demonstrationibus restitutis a Roberto Simson*, Glasgow, 1756, in 4to; 4. *Eléments de la Géométrie d'Euclide, ou les six premiers livres d'Euclide, avec le XI*^{e} *et le XII*^{e}, *traduction nouvelle par Frédéric Castillon*, Berlin, 1775, in 8vo. The other works of Euclid, printed separately, are, 1. *Euclidis Data, Claudius Hardy Græce nunc primum edidit, Latine vertit, scholiis illustravit; adjectus est Marini philosophi Commentarius, Græce et Latine*, Paris, 1625, in 4to; 2. *Euclidis Rudimenta Musices, Græce et Latine excusa, J. Pena interprete*, Paris, 1557, in 4to; 3. *Euclidis Introductio Harmonica, Græce etc. Meibomius vertit ac notis explicavit* in the *Antiqui Musicæ Auctores, VII.* Amsterdam, 1652, in 4to; 4. *Optica et Catoptrica, Græce et Latine reddita, per Jo. Penam*, Paris, 1557, in 4to. For further details see Murhard, *Bibliotheca Mathematica* (tom. ii. pp. 1–48), and other similar works. We have not thought it necessary to notice the more recent editions of the *Elements*, which are in the hands of every body. (A.)

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[1] Montucla, *Histoire des Mathématiques*, tom. i. p. 212 and 492.

[2] See *Nouveaux Eléments de la Géométrie*, and the Fourth Part of the *Logique Port-Royal.*

EUDIOMETER, an instrument for ascertaining the purity of the atmospherical air, or the quantity of oxygen contained in it, chiefly by means of its diminution, or the absorption produced by exposing certain substances to its action.

EUDOSIA, called ATHENIA before her conversion to Christianity, a celebrated lady, the daughter of Leontius, a philosopher of Athens, who gave her such a learned education that at his death he left her only a small legacy, saying she was capable of making her own fortune. Having pleaded at Athens without success against her two brothers for a share in her father's estate, she carried her cause personally by appeal to Constantinople, recommended herself to Pulcheria, the sister of the emperor Theodosius the Younger, embraced Christianity, was baptized by the name of *Eudosia*, and soon afterwards married to the emperor. This union lasted a considerable time; but a difference having at length taken place, on account of the emperor's jealousy, excited by Chrysapius the eunuch, Eu-

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[1] Lacroix, *Essais sur l'Enseignement en général, et sur celui des Mathématiques en particulier*, Paris, 1805.

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dosia retired to Jerusalem, where she spent many years in building and adorning churches, and in relieving the poor. Dupin says that she did not return thence till after the emperor's death; but Cave states that she was reconciled to him, returned to Constantinople, and continued with him till his death, after which she again retired to Palestine, where she spent the remainder of her life in pious works. According to Dupin, she died in the year 460; according to Cave, in 459. The latter observes that on her deathbed she took a solemn oath, by which she declared herself entirely free from any stains of unchastity. She was the author of a paraphrase in heroic verse on the first eight books of the Old Testament, and of a great number of poems, which are no longer extant.

EUDOXIANS, a party or sect of heretics in the fourth century, so denominated from their leader, Eudoxius, patriarch of Antioch and Constantinople, who was a great defender of the Arian doctrine. The Eudoxians adhered to the errors of the Arians and Eunomians, maintaining that the Son was created out of nothing, and that he had a will distinct and different from that of the Father.

EUGENE, François, commonly called Prince Eugene of Savoy, one of the greatest generals of his time (since he preceded Frederic II., and Turenne had fallen before he became known as a commander), was born at Paris on the 18th October 1663. His father, Eugene Maurice, count of Soissons, was grandson of the Duke of Savoy, Charles Emmanuel I.; and his mother, Olympia Mancini, was niece of Cardinal Mazarin; but the latter having been implicated in the affair of the poisonings, was forced to take refuge in Brussels in order to avoid prosecution. Originally destined for the church, Eugene evinced but little taste for theology, and occupied himself much more in reading the lives of great warriors, and the narratives of their exploits, than in studying the works of the fathers. Nevertheless he was of a feeble constitution; and as he wore a dark cloak, he was known at court hy the name of the Little Abbé. Louis XIV. refused him a company in a regiment of cavalry, because, according to some, he thought the young prince unfit for the profession of arms, whilst, according to others, this refusal was owing to the disgrace of his mother, and the hatred which Louvois bore to her. But however this may be, Eugene was so stung by the refusal, that, from the moment of his repulse, he conceived for the king and his minister that long and fatal resentment which at length caused so many evils to France.[1] Having quitted France in disgust, he proceeded to Vienna, where the Emperor Leopold, who was allied to his family, received him kindly, and granted him permission, along with several other Frenchmen of distinction, to serve against the Turks under the banners of Austria. His first campaign was that of 1683, during which his courage appeared so conspicuous that the emperor, by way of recompense, gave him a regiment of dragoons. After several other campaigns made with equal distinction, at the head of the same regiment, he became major-general; and it was in this capacity hat he served at the siege of Belgrade in 1688. At the nstigation of Louvois, a decree of banishment from France was now issued against all Frenchmen who should continue o serve in foreign armies. "I shall return into France in spite of him," said Eugene, when the news were communicated to him; and he continued to pursue with the same ardour the career on which he had entered in so brilliant a manner. In his case genius was stimulated by resentment.

Leopold, considering him as not less fitted for diplomacy than for war, sent Eugene as his envoy or negotiator to the Duke of Savoy, in order, if possible, to detach that prince from his connection with France. Nor did the result disappoint the expectations of the emperor. Overcome by the pressing solicitations of his young cousin, the duke allowed himself to be drawn so precipitately into the coalition against France, that, without waiting for the succours which the court of Vienna had promised him, he imprudently gave battle to Catinat at Staffarde, and was defeated, notwithstanding the great courage which Prince Eugene there displayed at the head of a corps of cavalry. But the auxiliary force sent by Austria having at length arrived, Eugene assumed the command, and, after obtaining some advantages, which placed the Duke of Savoy in a condition to defend himself, he returned to Vienna, where he decided the emperor to send fresh reinforcements. The imperial forces were thus put in a condition to resume the offensive; and Prince Eugene having arrived to command them in the spring of 1691, he caused the siege of Coni to be raised, took possession of Carmagnole, and gloriously terminated the struggle in which he had found himself engaged with Catinat. It was, in fact, as much by his successes, as by the ascendency which his superior mind exercised over the Duke of Savoy, that he managed to retain that prince in the coalition, from which he was oftener than once on the eve of breaking off, in order to throw himself again into the arms of France. Desirous to attach him still more to its interests, however, the court of Vienna conferred upon him the title of generalissimo of its forces; and it was in this capacity that he penetrated into Dauphiné at the head of ten thousand men, having Prince Eugene as his lieutenant. The combined army took possession of Embrun and Gap; laid the whole country in ashes, by way of reprisals for the burning of the Palatinate; and was preparing to carry its ravages even into Provence and Languedoc, when the generalissimo having been seized with the small-pox, this accident saved the French provinces from further devastation. Prince Eugene led the army back into Piedmont, and it was there that he received the brevet of field-marshal. After a third campaign of little importance, the Duke of Savoy having again joined the French, and thus turned the balance against the Austrians, Prince Eugene returned to Vienna, where he was appointed to the command of the army of Hungary.

It was about this time that Louis XIV. secretly offered him the baton of a marshal of France, with the government of Champagne, which his father had held, and also a pension of two thousand pistoles. But Eugene rejected these offers with indignation, and proceeded to combat the Turks commanded by the grand signior Kara-Mustapha in person. After some able marches and skilful manœuvres, he surprised the enemy at Zenta, on the Teisse, in a camp retrenched *en tête-de-pont;* and, after an attack as vigorous as it was daring, he killed twenty thousand of them, drove ten thousand into the river, made prisoners of the remainder, and took the whole of their artillery and equipages. Never had a more complete and decisive victory been obtained by the imperial arms. But this splendid achievement, at the same time that it fixed upon Prince Eugene the eyes of all Europe, inflamed to the last degree the jealousy of his rivals, or rather enemies, of whom he had many at court, some of them not less powerful than vindictive. By means of their intrigues, these persons had caused an order to be sent the prince, commanding him to suspend all attack; and this order had reached him an instant before the battle commenced, but without changing his determination to assault the enemy's position; the opportunity for striking a blow was propitious, and he boldly resolved to profit by it. This act of disobedience to the orders of the sovereign was doubtless a fault, and he who dared to commit it would have been ruined without resource had he not triumphed in a manner the most complete and decisive. But was not such a fault gloriously effaced by a victory as useful as it was brilliant? So at least thought all the world, excepting the enemies of Prince Eugene, who succeeded in persuading the emperor that nothing could excuse his disobedience; and, accordingly, when the victorious general appeared before his master, under the impression no doubt that he was to be greeted with acknowledgments and felicitations, he met with a cold and severe reception. Nor did the folly and ingratitude of his enemies stop here. Next day he was placed under arrest, and ordered to deliver up his sword; and he was about to be brought before a council of war, when the inhabitants of Vienna interposed, loudly remonstrating against the injustice of such treatment. The emperor also, whether from fear or repentance, relented, and restored his command to Prince Eugene, who, however, accepted it only on the condition that he should have *carte blanche.* It is alleged that when the envoy of the emperor came to demand his sword, he replied, "There it is, still reeking with the blood of the enemy; I consent not to resume it except for the advantage of his majesty's service." But it is now proved that this pretended reply is spurious; for, as the Prince de Ligne well observes, "one half of the phrase would have been a gasconade, and the other a meanness," neither of which comported with the simple and manly character of this great warrior. Prince Eugene then returned to Hungary; and, after a campaign distinguished by no remarkable event, a treaty of peace was at length concluded with the Turks at Carlowitz, on the 26th January 1699.

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[1] "Quelques historiens, bons ou mauvais, se donneront peut-être la peine d'entrer dans les détails de ma jeunesse, dont je ne me souviens presque plus. Ils parleront sûrement de ma mère, un peu intriguante à la vérité, chassée de la cour, exilée de Paris, et soupçonnée, je crois, de sorcellerie, par des gens qui n'étaient pas de grands sorciers. Ils diront comment je suis né en France, et comment j'en suis sorti, la rage dans le cœur contre Louis XIV., qui m'a refusé une compagnie de cavalerie, parce que, disait-il, avais une complexion trop faible; et une abbaye, parce qu'il prétendait (sur je ne sais quels mauvais propos sur mon compte, ou ausses anecdotes de galerie de Versailles) que j'étais plus fait pour le plaisir que pour l'église. Il n'y a de Huguenot chassé par la révocation de l'édit de Nantes, qui lui ait conservé plus de haine. Aussi, quand Louvois, apprenant mon départ, dit, *Tant mieux, il e rentra plus dans ce pays-ci*, je jurai bien de n'y rentrer que les armes à la main; j'ai tenu ma parole." (*Vie du Prince Eugene*, now nown to be the production of the Prince de Ligne.)

Having returned to Vienna, the prince applied himself to the study of the arts, and particularly of history, which had always great attractions for him. But he was not permitted long to enjoy the leisure which he seemed so desirous to improve. The war of the succession, which soon broke out, opened to him a new field of glory; and at the commencement of the year 1701, he was sent into Italy once more to oppose his old antagonist Catinat. But all the prudence of the old general failed to secure him against the bold and incessantly-renewed enterprises of his young and indefatigable rival. The latter effected, in presence of the French army, the passage of the Adige, and forced it, after sustaining several checks, to retire behind the Oglio, where a series of reverses equally unexpected and severe led to the disgrace and retirement of Catinat. The Duke of Villeroi succeeded to the command of which Catinat had been deprived, and the prince had soon reason to felicitate himself on a change which, from its first announcement, transported him with joy. The presumptuous Villeroi having ventured to attack him at Chiari, in an inexpugnable position, Eugene repulsed all his efforts without difficulty, and inflicted a severe loss on the assailants. And this first check was only the forerunner of more signal reverses; for, in a short time, Villeroi was forced to abandon the whole of the Mantuan territory, and to take refuge in Cremona, where he seems to have considered himself as secure in the midst of his staff. But, by one of the most audacious enterprises which has ever been attempted in war, this place was surprised, and, had it not been for untoward accidents, would unquestionably have been carried. By means of a stratagem, Prince Eugene penetrated into the city during the night, at the head of a numerous body; and it was only owing to circumstances which could not possibly be foreseen or provided against, and particularly to the courage and vigilance of some French officers, that he found himself at length compelled to retire, carrying along with him Villeroi as a prisoner. But this last circumstance, so far from being an advantage to the Imperialists, proved the reverse; the Duke of Vendôme replaced the captive general, and his ability soon changed the aspect of affairs. From the first moment Prince Eugene appreciated the talents of his new adversary; and, besides, being aware of the superiority of the French army, with which the king of Spain in person had just effected a junction at the head of numerous reinforcements, he confined himself to a war of observation, without important results, though fertile in most useful lessons to students of military science. This campaign was terminated by the battle of Luzara, fought on the 1st of August 1702, in which each party claimed the victory. It was one of the most sanguinary ever delivered by Prince Eugene, whose fortune it was to command in so many battles; he there lost the flower of his army, and also his best officers, including the brave Commerci, his intimate friend and most faithful companion in arms.

Both armies having entered into winter quarters, Eugene returned to Vienna, where he was appointed president of the council of war. He then set out for Hungary in order to combat the insurgents in that country; but his means proving insufficient, he effected nothing of importance. The revolt was, however, put down by the success which General Heister obtained in another quarter. Prince Eugene accordingly proceeded to Bavaria, where, in 1704, he made his first campaign along with Marlborough. Similarity of tastes, views, and talents soon established between these two great men a friendship which is rarely to be found amongst military chiefs, and which contributed more than all other causes put together to the success which the allies obtained. The first and perhaps the most important of these successes was that of Hochsett or Blenheim, gained on the 13th of August 1704, where the English and imperial troops triumphed over one of the finest armies which France had as yet sent into Germany. See MARLBOROUGH.

But since Prince Eugene had quitted Italy, Vendôme, who commanded the French army in that country, had obtained various successes. The Duke of Savoy, who had once more deserted France and joined Austria, had suffered severe losses; and the emperor having decided to send him assistance, Piedmont thus became the principal theatre of active hostilities. Having received orders to proceed thither without delay, Eugene quitted Marlborough with the most lively regret, though at the same time experiencing a secret satisfaction at the prospect of measuring himself with a rival in all respects worthy of him. Vendôme at first opposed great obstacles to the plan which the prince had formed for carrying succours into Piedmont; but after a variety of marches and countermarches, in which both commanders displayed signal ability, the two armies met at Cassano, where a murder-ous engagement ensued, and Prince Eugene received two severe wounds, which forced him to quit the field. This accident decided the fate of the battle, and for the time suspended the prince's march towards Piedmont. But although prevented from effecting a junction with the Duke of Savoy, his operations failed not to prove advantageous to that prince, since the Duke de la Feuillade, then besieging Turin, was obliged to raise the siege and march to the assistance of Vendôme, who, notwithstanding his victory at Cassano, felt apprehensive of some new and daring enterprise on the part of his antagonist. Vendôme, however, was recalled, and La Feuillade was incapable of long arresting the progress of such a commander as Eugene. After once more passing several rivers in presence of the French army, and executing one of the most skilful and daring marches he had ever performed, the latter appeared before the entrenched camp at Turin, which place the French were now besieging with an army eighty thousand strong. Prince Eugene had only thirty thousand men; but his antagonist was the Duke of Orleans, who, though full of zeal and courage, wanted sufficient experience to enable him to contend with a man justly regarded as one of the greatest warriors of his time. Besides, by a secret order of Louis XIV., who had, in fact, transferred the command to Marsin, the young prince was restricted to the execution of an ill-conceived plan, which neutralized the advantage of superior numbers, and put it in the power of the enemy to select his point of attack. With equal courage and address, Eugene profited by the misunderstanding which the exhibition of such an order could not fail to produce between the French generals; and having on the 7th September 1706 attacked the French army in its entrenchments, he gained a complete victory, which decided the fate of Italy. This brilliant achievement, the result of the most masterly combinations, and, in several respects, the prototype of the campaign of Marengo in 1800, affords one of the most remarkable examples of the difficulty of defending extensive lines even against an inferior army, massed upon one or two points. As soon as the Duke of Orleans observed the imperial army approaching, he wished to march out of the lines with the whole French army, and to deliver battle in the open field, where he could have availed himself of his great numerical superiority (eighty thousand to thirty); but he was restrained by Marsin, who, by this absurd interposition, sealed the fate of the French army, and lost Italy. In the heat of the battle, which almost immediately ensued, Eugene received a wound, and was thrown from his horse into a ditch. His fall produced a belief that he was killed, and his soldiers began to lose courage; but he soon returned to the attack, and when the soldiers saw him appear in the midst of them covered with slime and blood, issuing his orders, and watching over every thing with the most admirable sang-froid, their enthusiasm was raised to the highest pitch; and from that moment the issue of the battle was certain. As a recompense for so important services, the prince received the government of the Milanese, of which he took possession with great pomp on the 16th April 1707.

The attempt which he made against Toulon, in the course of the same year, failed completely, because the invasion of the kingdom of Naples retarded the march of the troops which were to have been employed in it, and this delay afforded Marshal de Tessé time to make good dispositions. Obliged to renounce his project, therefore, the prince repaired to Vienna, where he was received with great enthusiasm both by the people and the court. "I am very well satisfied with you," said the emperor, "excepting on one point only, which is, that you expose yourself too much." This monarch immediately dispatched Eugene to Holland, and to the different courts of Germany, in order to forward the necessary preparations for the campaign of the following year, 1708.

Early in the spring of 1708 the prince proceeded to Flanders, in order to assume the command of the forces which his diplomatic ability had been mainly instrumental in assembling. This campaign was opened by the victory of Oudenarde, to which the perfect union of Marlborough and Eugene on the one hand, and the misunderstanding between Vendôme and the Duke of Burgundy on the other, seem to have equally contributed. This prince immediately abandoned the Low Countries, and remaining in observation, made no attempt whatever to raise the siege of Lille, where Boufflers distinguished himself by a glorious defence. To the valour of the latter Eugene paid the most marked and flattering homage, at the same time loading him with all those expressions of esteem and regard with which it was then usual, in such cases, to attemper the horrors of war. Boufflers was invited by his enemies to prepare the articles of capitulation himself, and Prince Eugene wrote to him, "I subscribe to every thing beforehand, well persuaded that you will not insert any thing unworthy of yourself or of me." After this important conquest, Eugene and Marlborough proceeded to the Hague, where they were received in the most flattering manner by the public, by the states-general, and, above all, by their esteemed friend the pensionary Heinsius. Negotiations were then opened for peace, but as the conditions proposed by the allies were considered by Louis XIV. as alike degrading to himself and to France, both parties made preparations for continuing the war.

The campaign of 1709 was opened in Flanders by two hostile armies, each a hundred and fifty thousand strong. That of the French was commanded by Villars, a man of considerable talents, but of little experience, and who feared to compromise himself in opposition to such great captains as Marlborough and Eugene. He accordingly remained upon the defensive, and suffered them to take Tournay without opposition; but being desirous of succouring Mons, he was followed by the allies, who attacked him at Malplaquet on the 9th of September, in a formidable position, where he had had time to entrench himself. The attack was made with equal vigour and ability; but owing to the strength of the French position, and the tenacity with which it was maintained, the victory was purchased at the cost of twenty-five thousand men killed on the field of battle, and the Dutch infantry was almost annihilated. The battle of Malplaquet was to it what the battle of Rocroi had been to the infantry of Spain; and it never afterwards recovered from the effects of that sanguinary day. Although the allies remained masters of the field of battle, this barren advantage had been so dearly bought, that they found themselves soon afterwards out of all condition to undertake any thing. Their army accordingly went into winter-quarters, and Prince Eugene returned to Vienna, whence the emperor almost immediately dispatched him to Berlin. From the king of Prussia the prince obtained every thing which he had been instructed to require; and having thus fulfilled his mission, he returned into Flanders, where, excepting the capture of Douay, Bethune, and Aire, the campaign of 1810 presented nothing remarkable. The emperor Joseph I. having died about this time, Prince Eugene, in concert with the empress, exerted his utmost endeavours to secure the crown to the archduke, who afterwards ascended the imperial throne under the name of Charles VI.

In the year following, 1711, the changes which had occurred in the policy, or rather the caprice, of Queen Anne, brought about an approximation between England and

France, and put an end to the influence which Marlborough had hitherto possessed with that princess. When this political revolution became known, Prince Eugene immediately repaired to London, charged with a mission from the emperor, and there made strenuous efforts to re-establish the credit of his illustrious companion in arms, as well as to re-attach England to the coalition. But all arguments and persuasions, whether founded on views of interest or sentiments of honour and consistency, having proved unavailing, the emperor found himself under the necessity of making the campaign of 1712 with the aid of the Dutch alone. The defection of the English, however, did not induce Prince Eugene to abandon his favourite plan of invading France. He had long been decided to make any sacrifice to accomplish this design, the conception of which originated as much, perhaps, in resentment as in a passion for glory. He therefore resolved, at whatever cost, to penetrate into Champagne; and in order to support his operations by the possession of some important places, he began by making himself master of Quesnoy. But the Dutch having been surprised and beaten in the lines of Denain, where Prince Eugene had placed them at too great a distance to receive timely support in case of an attack, he was obliged to raise the siege of Landrecies, and to abandon the project which he had so long cherished. This was the last campaign in which Austria acted in conjunction with her allies. Abandoned first by England and then by Holland, the emperor, notwithstanding these desertions, still wished to maintain the war in Germany; but the superiority of the French army prevented Eugene from relieving either Landau or Friburg, which were successively obliged to capitulate; and seeing the empire thus laid open to the armies of France, and even the hereditary states themselves exposed to invasion, the prince counselled his master to make peace. Sensible of the prudence of this advice, the emperor immediately entrusted Eugene with full powers to negotiate a treaty; and after some interviews, in which the prince and Villars interchanged expressions of esteem and admiration, there was concluded at Rastadt, on the 6th of March 1714, a peace which had long been anxiously looked for, and of which the nations of Europe had the greatest need.

After this happy event, Prince Eugene went to enjoy at Vienna some moments of repose. The emperor continued to show him marks of the most entire confidence; and from this time adopted no resolution, either in regard to the administration of the army, or that of the interior, without consulting him. But this kind of occupation did not suit the activity of Eugene; and although he was now advanced in years, his warlike humour had lost nothing of its vivacity. Sensible of the impossibility of Austria, situated as she was, resisting France, he had done all in his power to accelerate the conclusion of peace; but, by a contrary species of reasoning, he availed himself of a petty quarrel which the Ottoman Porte had with the Venetians to determine his master to espouse the cause of the latter. The emperor, having taken this step, appointed Eugene to command the army of Hungary; and at Peterwaradin, with a force not exceeding sixty thousand men, he gained a signal victory over the Turks, who had not less than a hundred and fifty thousand men in the field. This victory made a great noise in Europe, and all the Christian powers conceived themselves bound to rejoice on account of it. The pope sent to the victorious general the consecrated rapier, which the court of Rome was accustomed to bestow upon those who had triumphed over the infidels; and this extraordinary present was put into the hands of Prince Eugene by an envoy of his holiness. But the ensuing campaign, being that of 1717, was still more remarkable, on account of the battle of Belgrade. After having remained under the walls of that city, in a situation the most difficult imaginable; after having resisted, during a month, the efforts of a numerous garrison, as well as those of a hundred and fifty thousand Turks, with an army of only forty thousand men; and after having lost nearly the half of his troops by dysentery, and the fire of the Ottoman artillery, which plunged its shot even into his own tent; Prince Eugene gained one of the most complete victories of which there is any record or tradition, and soon afterwards forced Belgrade itself to capitulate. The attack which he ordered against forces six times more numerous than his own was really an act of despair. He had himself been seized with the cruel malady which was destroying his army, and all was consternation in the Austrian camp; yet at the very moment when he was believed to be on the eve of capitulating, he succeeded, by his constancy and daring courage, in obtaining a most decisive victory. The prince was wounded in the heat of the action, this being the thirteenth time that he had been hit upon the field of battle. On his return to Vienna he received numerous testimonies of gratitude, and, amongst others, a sword valued at eighty thousand florins, which was presented to him by the emperor. In the following year, 1718, after some fruitless negotiations with a view to the conclusion of peace, he again took the field; but the treaty of Passarowitz put an end to hostilities, at the moment when the prince had well-founded hopes of obtaining still more important successes than those which had illustrated the last campaign, and when he even flattered himself with reaching Constantinople, and dictating a peace on the shores of the Bosphorus. On his return to Vienna he was, as usual, received with every mark of esteem and admiration.

As the government of the Low Countries, formerly conferred upon Eugene, had now for some reason been bestowed on a sister of the emperor, the prince was appointed vicar-general of Italy, with a pension of three hundred thousand florins. From this time he occupied himself much more than he had ever done with the affairs of government; and Charles VI. habitually consulted him in all affairs of importance. He accompanied this monarch in several journeys, particularly to Prague, where Frederick I. of Prussia met the emperor by appointment, and testified the greatest admiration of the veteran warrior, by whom the latter was attended; and his influence seemed to be in all respects commensurate with his fame. During the ten years of peace which ensued, Eugene occupied himself with the arts and with literature, to which he had hitherto been able to devote little of his time. But the contest which arose out of the succession of Augustus II. to the throne of Poland having afforded Austria a pretext for attacking France, war was resolved on, contrary to the advice of Prince Eugene, whose last campaigns had taught him to dread the efforts of that power. Yet, although he had in the council declared his opinion in favour of peace, he was appointed to command the army destined to act upon the Rhine. This army, from the commencement, had very superior forces opposed to it; and if it could not prevent the capture of Philipsburg after a long siege, it at least prevented the enemy from entering Bavaria. Prince Eugene, having now attained his seventy-first year, no longer possessed the vigour and activity necessary for the command of armies; he himself perceived the change which time had wrought in his powers; and as he now longed for and required repose, he applied himself to bring about a peace, which was at length concluded on the 3d of March 1733. Having returned to Vienna, his health declined more and more, and he died in that capital on the 21st April 1736, leaving an immense succession to his niece the Princess Victoria of Savoy.

Of a character cold and severe, Prince Eugene had almost no other passion than that of glory. He died unmarried, and without having ever evinced the slightest partiality for any woman, excepting, perhaps, the Countess de Bathiani, who, by the attractions of her wit and vivacity, appears to have consoled the last moments of his life. Although one of the greatest warriors of his time, military science is not indebted to him for any remarkable improvement. His operations were not directed according to any positive method, nor conformable to invariable principles; it was by sudden inspirations, and an admirable rapidity of *coup d'œil*, that he conducted himself on the ground according to the circumstances and the men with whom he had to deal; and upon all occasions he took the greatest pains to ascertain the character of the generals who were opposed to him. This system of tactics chiefly resembles that which we have seen displayed in the recent wars; it exhibits neither the prudence and circumspection of Turenne, nor the astonishing strategic ability of Frederick, in the difficult art of putting in motion and deploying columns and lines: it consists merely in an incessant activity and audacity, united with an admirable promptitude in perceiving and repairing faults. Despising the lives of his soldiers as much as he exposed his own, it was always by persevering efforts and great sacrifices that he obtained victory. To the Austrian armies he gave an eclat which they had never before possessed, and which, as it was reflected from his character alone, died with him; in fact, he could not sustain himself without efforts which wars so protracted and destructive rendered impossible upon the part of the people of Austria. This exhaustion, indeed, was long felt in the Austrian monarchy; and as that power has not had a single general since the time of Prince Eugene who can at all be compared with him, its armies have not subsequently been illustrated by any remarkable event, and the reputation of this general has consequently stood far above that of all other commanders in the imperial service. Prince Eugene, in truth, had a prevailing passion for war. Always on the march, in camps, or on the field of battle during more than fifty years, and under the reign of three emperors, he had scarcely passed two years together without fighting. It has been said that he loved letters and the arts; and the protection which he afforded to J. B. Rousseau has often been cited as a proof of this commendable taste. It is certain, indeed, that in his numerous expeditions, he had made an immense collection of objects interesting to science and art, as well as of valuable books and manuscripts; but it is evident that he never took time to examine them; and there is nothing to prove that he knew how to appreciate their value. He profited by war, which, in every point of view, prodigiously enriched him; and if he must be ranked with Turenne, Vendôme, and Catinat in regard to personal valour, he cannot be compared with them in point of disinterestedness and generosity. Prince Eugene was a man of the middle size, but, upon the whole, well made; the cast of his visage was somewhat ong, his mouth moderate, and almost always open; his eyes were black and animated, and his complexion such as became a warrior. His funeral oration, composed in Italian by Cardinal Passionei, was translated into French by Madame du Boccage, 1759, in 12mo. But the most complete work on his life is the *Histoire du Prince Eugène*, Amsterdam, 1740, and Vienna, 1755, which was published anonymously, though it is now known to be the compilaion of a M. de Mauvillon. It was from this production hat the Prince de Ligne derived the greater part of the writing which he published in Germany in 1809, and which was twice printed the year following at Paris, under the title of *Vie du Prince Eugène de Savoie, écrite par lui-même*, in one vol. 8vo. There exists in German a history of Prince Eugene, which is little esteemed; and there was also published at Nuremberg, in 1738, a work entitled *Eugenius nummis illustratus*, which is of little value. But the Italian work on the Life and Campaigns of Prince Eugene, published at Naples in 1754, 8vo, is much more exact. We have also *Campagnes du Prince Eugène en Hongrie*, in 2 vols. 8vo; and *Histoire Militaire du Prince Eugene, du Duc de Marlborough, et du Prince de Nassau*, 2 vols. fol. by Dumont, and continued by Rousseau, Hague, 1729. The work of Father Ferrari, entitled *De Rebus Gestis Eugenii Principis Sabaudiæ, Bello Pannonico*, is much more remarkable for the purity of the style than for the accuracy of the facts. (A.)

EUGUBIAN, or EUGUBINE TABLES, *Tabulæ Eugubinæ*, inscribed tablets in bronze, found in 1444 at La Schieggia, near Gubbio (*Eugubium*), in the duchy of Urbino. These tablets are seven in number, five of them containing inscriptions in Umbric, mixed with Etruscan, and the remaining two inscriptions in Latin characters. They were at first believed to be of very high antiquity; but it is now pretty generally agreed that they are not more ancient than the fourth century before the Christian era. The learned reader will find copies of these remarkable monuments in Dempster's *Etruria Regalis* (vol. i. p. 91, et seqq.), and also some curious details respecting them in the supplement to that work by the senator Buonarotti (vol. ii. p. 101). According to Lanzi, they refer entirely to the mode of sacrifice, the particular forms of prayer, and other religious rites of certain Umbrian communities, who were united in a sort of federal bond; but the explanations of the learned Italian are much too arbitrary and hypothetical to be of any authority; and, in point of fact, we are still as ignorant of the *language* of these inscriptions as when the tablets were first discovered, nearly four centuries ago. (See article ETRUSCANS.) But as the character has proved less untractable than the text, an Etruscan alphabet has been constructed, by means of which we are enabled to read the words which as yet we cannot interpret. Previously to the time (1732) when Bourguet undertook this difficult task, several persons had attempted it, and failed. But, by carefully comparing the tablets in the Roman character with those in the Etruscan, the ingenious Frenchman discovered that the former were a compendium of the latter, and that many words were common to both sets; and, having obtained this key, he succeeded, by pursuing the comparison he had instituted, in constructing an alphabet which, though far from being complete, was yet much more perfect than any which had preceded it. Since the time of Bourguet, however, no further progress has been made in this confined but interesting field of inquiry; and as the language has hitherto baffled every artifice of interpretation, the contents of these curious monuments of antiquity still remain undeciphered. The discovery of a bilingual inscription, which is not an impossible event, would, however, furnish the needful key, and lead directly to the solution of an enigma alike vexatious and interesting to the scholar. Should this ever happen, or should some rare effort of sagacity or miracle of fortune unexpectedly put any inquirer on the right road without such aid, we venture to prognosticate that the language of these inscriptions will be found to be radically Celtic, perhaps a dead dialect of that language, intermixed with terms of Pelasgic origin. That the Umbri were Celts, or at least of Celtic origin, there can be little doubt; and it seems equally certain that the Etruscans, who ultimately predominated over all the other tribes which from time to time had settled in

Etruria, were also, in part at least, of northern descent. It would therefore be strange indeed if in these inscriptions, five of which are in the Umbric mixed with the Etruscan character, no traces were found of that primitive language which successive immigrations from the north must have diffused over a considerable portion of the great plain of Italy. The Eugubine Tables were first published by Smetius, 1588; then by Gruter, *Inscript.* vol. i. p. 142. (Bourguet, *Dissert. Mem. Cort.* tom. i. p. 1; Dempster, *De Etruria Regali*, ubi supra; and Lanzi, *Saggio di Lingua Etrusca*. See also *Beitrage zur Deutung der Eugubinischen Tafeln* von Lassen. Bonn, 1833.) (A.)

EULER, Leonard, professor of mathematics, member of the Imperial Academy of Petersburg, ancient director of the Royal Academy of Berlin, and fellow of the Royal Society of London, as also a corresponding member of the Royal Academy of Sciences at Paris, was born at Basil on the 15th of April 1707, of reputable parents. The years of his infancy were passed in a rural retreat at the village of Richen, of which place his father was minister. Being sent to the university of Basil, he attended regularly the different professors; and as his memory was prodigious, he performed his academical tasks with uncommon rapidity; but all the time he thus gained was consecrated to geometry, which soon became his favourite study. The early progress which he made in this science only gave new ardour to his application; and thus he obtained a distinguished place in the esteem of John Bernoulli, who was at that time one of the first mathematicians in Europe, as well as in the friendship of Daniel and Nicolas Bernoulli, who were already the rivals of their illustrious father. In 1723 Euler took his degree as master of arts, and delivered on that occasion a Latin discourse, in which he drew a comparison between the philosophy of Newton and the Cartesian system, which was received with the greatest applause. At his father's desire he afterwards applied himself to the study of theology and the oriental languages, and though these studies were foreign to his predominant propensity, his success was considerable; but, with his father's consent, he returned to geometry as his principal pursuit. He continued to avail himself of the counsels and instructions of John Bernoulli; he contracted, as already stated, an intimate friendship with his two sons, Daniel and Nicolas; and it was in consequence of these connexions that he became afterwards the principal ornament of the Academy of Petersburg. The project of erecting this academy, which had been formed by Peter the Great, was executed by Catherine I.; and the two young Bernoullis being invited to Petersburg in 1725, promised Euler, who was desirous of following them, that they would use their utmost endeavours to procure for him an advantageous settlement in that city. In the mean time, by their advice, he applied himself with ardour to the study of physiology, to which he made a happy application of his mathematical knowledge; and he also attended the medical lectures of the most eminent professors of Basil. This study, however, did not wholly engross his time, nor even relax the activity of his powerful and comprehensive mind in the cultivation of other branches of natural science. For whilst he was keenly engaged in physiological researches, he composed a dissertation on the nature and propagation of sound, and an answer to a prize-question concerning the masting of ships, to which the Academy of Sciences adjudged the *accessit*, or second rank, in the year 1727. From this latter discourse, and other circumstances, it appears that Euler had early embarked in the curious and important study of navigation, which he afterwards enriched with so many valuable discoveries.

Euler's merit would have given him an easy admission to honourable preferment, either in the magistracy or university of his native city, if both civil and academical honours had not been there distributed by lot. But chance having decided against him in regard to a certain situation to which he aspired, he left his country, set out for Petersburg, and was made joint professor with his countrymen Hermann and Daniel Bernoulli in the university of that city. At the commencement of his new career he enriched the academical collection with many memoirs, which excited a noble emulation between him and the Bernoullis; and this emulation always continued, without either degenerating into a selfish jealousy, or producing the least alteration in their friendship. It was at this time that he carried to a new degree of perfection the integral calculus, invented the calculation of sines, reduced analytical operations to a greater simplicity, and threw new light on all the parts of mathematical science. In 1730 he was promoted to the professorship of natural philosophy; and in 1733 he succeeded his friend Daniel Bernoulli in the mathematical chair. In 1735 a problem was proposed by the academy which required expedition, and for the solution of which several eminent mathematicians had demanded the space of some months. The problem was solved by Euler in three days, to the great astonishment of the academy; but the violent and laborious efforts it cost him threw him into a fever, which endangered his life, and deprived him of the use of his right eye. The Academy of Sciences at Paris, which in 1738 had adjudged the prize to his memoir concerning the nature and properties of fire, proposed for the year 1740 the important subject of the tides; a problem the solution of which required the most arduous calculations, and comprehended the theory of the solar system. Euler's discourse on this question was considered as a masterpiece of analysis and geometry; and it was more honourable for him to share the academical prize with such illustrious competitors as Colin Maclaurin and Daniel Bernoulli, than to have carried it away from rivals of inferior reputation. Rarely if ever did such a brilliant competition adorn the annals of the academy; and no subject, perhaps, proposed by that learned body, was ever treated with such accuracy of investigation and force of genius, as that which here displayed the philosophical powers of these three extraordinary men.

In the year 1741 Euler was invited to Berlin in order to augment the lustre of the academy which was there rising into fame. He enriched the last volume of the *Mélanges* or Miscellanies of Berlin with five memoirs, which make an eminent, perhaps the principal, figure in that collection; and these were followed, with an astonishing rapidity, by a great number of important researches, which are scattered throughout the memoirs of the Prussian academy, of which a volume was regularly published every year. The labours of Euler will appear more astonishing when it is considered, that whilst he was enriching the Academy of Berlin with a prodigious number of memoirs on the deepest parts of mathematical science, containing always some new views, often sublime truths, and sometimes discoveries of great importance, he did not discontinue his philosophical contributions to the Academy of Petersburg, which granted him a pension in 1742, and the memoirs of which display the marvellous fecundity of Euler's genius. It was with much difficulty that this great man obtained, in 1766, permission from the king of Prussia to return to Petersburg, where he desired to pass the remainder of his days. Soon after his return, which was graciously rewarded by the munificence of Catherine II., he was seized with a violent disorder, which terminated in the total loss of his sight. A cataract, having formed in his left eye, which had been essentially

Euler.

damaged by a too ardent application to study, deprived him entirely of the use of that organ. It was in this distressing situation that he dictated to his servant, a tailor's apprentice, who was absolutely devoid of mathematical knowledge, his *Elements of Algebra;* which, by their intrinsical merit in point of perspicuity and method, and the unhappy circumstances in which they were composed, have excited equal applause and astonishment. This work, though purely elementary, discovers the characteristics of an inventive genius; and it is here alone that we meet with a complete theory of the analysis of Diophantus.

About this time Euler was honoured by the Academy of Sciences at Paris with the place of foreign member of that learned body; and after this, the academical prize was adjudged to three of his memoirs, *Concerning the Inequalities in the Motions of the Planets.* The two prize-questions proposed by the same academy for 1770 and 1772 were designed to obtain from the labours of astronomers a more perfect theory of the moon. Euler, assisted by his eldest son, was a competitor for these prizes, and obtained both. In this last memoir he reserved for further consideration several inequalities of the moon's motion, which he could not determine in his first theory, on account of the complicated calculations in which the method he then employed had engaged him. But he had the courage afterwards to review his whole theory, with the assistance of his son and Messrs Krafft and Lexell, and to pursue his researches until he had constructed the new tables, which appeared, together with the great work, in 1772. Instead of confining himself, as before, to the fruitless integration of three differential equations of the second degree, which are furnished by mathematical principles, he reduced them to the three ordinates, which determine the place of the moon; and he divided into classes all the inequalities of that planet, as far as they depend either on the elongation of the sun and moon, or upon the eccentricity, or the parallax, or the inclination of the lunar orbit. All these means of investigation, employed with such art and dexterity as could only be expected from analytical genius of the first order, were attended with the greatest success; and it is impossible to observe without admiration such immense calculations on the one hand, and on the other the ingenious methods employed by this great man to abridge them, and to facilitate their application to the real motion of the moon. But this admiration will become astonishment when we consider at what period and in what circumstances all this was effected. It was when he was totally blind, and consequently obliged to arrange all his computations by the sole powers of his memory and his genius; when he was embarrassed in his domestic circumstances by a dreadful fire, which had consumed the greater part of his substance, and forced him to quit a ruined house, every corner of which was known to him by a habit that in some measure supplied the place of sight;—it was in these circumstances, and under these privations, that Euler composed a work, which alone is sufficient to render his name immortal. The heroic patience and tranquillity of mind which he displayed need no eulogy here; and he derived them not only from the love of science, but from the power of religion. His philosophy was too genuine and sublime to stop its analysis at mechanical causes; it led him to that divine philosophy of religion which ennobles human nature, and is alone capable of forming a habit of true magnanimity and patience under suffering.

Some time after this the celebrated Wenzell, by couching the cataract, restored Euler's sight; but the satisfaction and joy which this successful operation produced were of short duration. Some instances of negligence on the part of his surgeons, and his own impatience to use an organ the cure of which was not complete, deprived him of vision a second time; and this relapse was accompanied with tormenting pain. With the assistance of his sons, and of Messrs Krafft and Lexell, however, he continued his labours; neither the loss of his sight nor the infirmities of an advanced age being sufficient to damp the ardour of his genius. Having engaged to furnish the Academy of Petersburg with as many memoirs as would be sufficient to complete its acts for twenty years after his death, he in the space of seven years transmitted to the academy above seventy memoirs, and left above two hundred more, which were revised and completed by the author of this notice. Such of the memoirs as were of ancient date were separated from the rest, and form a collection which was published in the year 1783, under the title of *Analytical Works.*

Euler's knowledge was more universal than could well be expected in one who had pursued with such unremitting ardour mathematics and astronomy as his favourite studies. He had made very considerable progress in medical, botanical, and chemical science; he was an excellent scholar, and possessed what is generally called erudition in a very high degree. He had read, with attention and taste, the most eminent writers of ancient Rome; the civil and literary history of all ages and all nations was familiar to him; and foreigners who were only acquainted with his works were astonished to find in the conversation of a man whose long life seemed to have been wholly occupied in mathematical and physical researches and discoveries, such an extensive acquaintance with the most interesting branches of literature. In this respect, no doubt, he was much indebted to an uncommon memory, which seemed to retain every idea that was conveyed to it, either from reading or meditation. He could repeat the Æneid of Virgil from the beginning to the end without hesitation, and indicate the first and last line of every page of the edition which he used.

But several attacks of vertigo, in the beginning of September 1783, which did not prevent his calculating the motions of the aerostatical globes, proved the forerunners of his mild and happy passage from this scene to a better. His death was sudden; he ceased to calculate and to live at nearly the same instant of time. Whilst he was amusing himself at tea with one of his grandchildren, he was struck with apoplexy, which terminated his illustrious career at the age of seventy-six. Euler, says Condorcet, was one of those men whose genius was equally capable of the greatest efforts and of the most continued labour; who multiplied his productions beyond what might have been expected from human strength, and who notwithstanding was original in each; whose head was always occupied, and his mind always calm. The nature of his pursuits, by withdrawing him from the world, preserved that simplicity of manners for which he was originally indebted to his character and his education; and he employed none of those means to which men of real merit have sometimes recourse in order to enhance the importance of their discoveries. It is true that fecundity such as his renders useless all the little calculations of self-love; but still great lucidity of mind and uprightness of character are necessary to trace, as he has done, the history of his thoughts, even when his investigations have proved fruitless, or the results disappointed the expectations which he had formed. Euler's constitution was uncommonly vigorous; his health was good; and the evening of his long life was serene, being sweetened by the fame which follows genius, the public esteem and respect which are never withheld from exemplary virtue, and several domestic comforts, which he was capable of feeling, and therefore deserved to enjoy.

The works which Euler published separately are, 1. *Dissertatio physica de Sono*, Bâle, 1727, in 4to; 2. *Mechanica, sive Motûs scientia, analytice exposita*, Petersburg, 1736, in 2 vols. 4to; 3. *Einleitung in die Arithmetik*, or Introduction to Arithmetic, ibid. 1738, 2 vols. 8vo, in German and Russian; 4. *Tentamen Novæ Theoriæ Musicæ*, ibid. 1739, in 4to; 5. *Methodus inveniendi Lineas curvas, maximi minimive proprietate gaudentes, sive solutio problematica isoperimetrici latissimo sensu accepti*, Lausanne, 1744, in 4to; 6. *Theoria motuum Planetarum et Cometarum, continens methodum facilem ex aliquot observationibus orbitas*, etc. *determinandi*, Berlin, 1744, in 4to; 7. *Beantwortung*, etc. or Answers to different Questions respecting Comets, ibid. 1744, in 8vo; 8. *Neue Grundsætze*, etc. or New Principles of Artillery, translated from the English of Benjamin Robins, with notes and illustrations, ibid. 1745, in 8vo; 9. *Opuscula varii argumenti*, ibid. 1746–1751, in 3 vols. 4to; 10. *Novæ et correctæ Tabulæ ad loca Lunæ computanda*, ibid. 1746, in 4to; 11. *Tabulæ Astronomicæ Solis et Lunæ*, ibid. 4to; 12. *Gedanken*, etc. or Thoughts on the Elements of Bodies, ibid. 4to; 13. *Rettung der Gottlichen Offenbarung*, etc. Defence of Divine Revelation against Freethinkers, ibid. 1747, in 4to; 14. *Introductio in Analysin Infinitorum*, Lausanne, 1748, in 2 vols. 4to; 15. *Scientia Navalis, seu Tractatus de construendis ac dirigendis Navibus*, Petersburg, 1749, in 2 vols. 4to; 16. *Theoria motûs Lunæ*, Berlin, 1753, in 4to; 17. *Dissertatio de principio minimæ actionis, una cum examine Objectionum cl. prof. Kœnigii*, ibid. 1753, in 8vo; 18. *Institutiones Calculi Differentialis, cum ejus usu in analysi Infinitorum ac doctrina Serierum*, ibid. 1755, in 4to; 19. *Constructio Lentium Objectivarum*, etc. Petersburg, 1762, in 4to; 20. *Theoria motûs Corporum solidorum seu rigidorum*, Rostoch, 1765, in 4to; 21. *Institutiones Calculi Integralis*, Petersburg, 1768–1770, in 3 vols. 4to; 22. *Lettres à une Princesse d'Allemagne sur quelques sujets de Physique et Philosophie*, Petersburg, 1768–1772, in 3 vols. 8vo; 23. *Anleitung zur Algebra*, or Introduction to Algebra, Petersburg, 1770, in 8vo; 24. *Dioptrica*, Petersburg, 1767–1771, in 3 vols. 4to; 25. *Theoria motuum Lunæ nova methodo pertractata*, ibid. 1772, in 4to; 26. *Novæ Tabulæ Lunares*, ibid. in 8vo; 27. *Théorie complète de la construction et de la manœuvre des Vaisseaux*, ibid. 1773, in 8vo; 28. *Eclaircissements sur les établissements en faveur tant des Veuves que des Morts*, without a date; 29. *Opuscula Analytica*, Petersburg, 1783–1785, in 2 vols. 4to.

EULOGY, Eulogia, in *Ecclesiastical History*. When the Greeks cut a loaf or piece of bread to consecrate it, they broke the rest into little bits, and distributed it among the persons who had not yet communicated, or sent it to persons who were absent; and these pieces of bread were what they called *eulogies*. The word is Greek, *ευλογια*, formed from ευ, *bene*, well, and λεγω, *dico*, I say or speak; meaning *benedictum*, or blessed. The Latin church, for a great many ages, had something like eulogies; and thence arose the use of the holy bread. The name *eulogy* was likewise given to loaves or cakes brought to church by the faithful to have them blessed. Lastly, the use of the term passed hence to mere presents made to a person without any benediction.

Eulogy likewise means an encomium pronounced on any person by reason of some virtue or good quality.

EUMARIDES, from ευμαρης, *easy* or *convenient*, among the ancients, a kind of shoes common to men and women. The eumarides were used for pomp and delicacy, being neat, and painted with various colours.

EUMENES, a native of Cardia, a city in the Thracian Chersonesus, was born 360 and died 315 B. C. At a very early age he was employed as private secretary by Philip king of Macedonia, on account of his friendship for his father. On the death of that prince he was confirmed in the same office by Alexander; and it was in this capacity that he accompanied that monarch into Asia. So highly did Alexander esteem him that he gave him in marriage a Persian lady of noble birth, sister to her who had married Ptolemy. Upon the death of Alexander, the provinces and armies were divided amongst his generals, and the countries assigned to Eumenes were Cappadocia and Paphlagonia, with the sea-coast of Pontus as far as Trapezus; but as they were not yet subdued, Leonatus and Antigonus were commissioned to put him in possession. Antigonus disregarded the orders of Perdiccas, and Leonatus having in vain attempted to induce Eumenes to accompany him to the assistance of Antipater in Europe, made an unsuccessful attack on his life. Eumenes escaped and joined Perdiccas, who assisted him in taking possession of Cappadocia.

About this time Craterus and Antipater, having reduced Greece, determined to pass into Asia and overthrow the power of Perdiccas. It may be easily imagined that Cappadocia was the first object of their attack; and accordingly Eumenes was appointed commander of all the forces in the neighbouring countries. But to this Neoptolemus, one of the generals, refused to submit; and being defeated by Eumenes, he fled to Antipater and Craterus. The presence of Antipater was required in Cilicia, and the army destined to act against Eumenes was therefore commanded by Craterus and Neoptolemus. They were, however, completely defeated; Neoptolemus was killed, and Craterus died of his wounds, 321 B.C. The pride of the Macedonians was hurt by this defeat of two of their generals by a person whom they considered as a stranger; and the news having reached them a few days after the death of Perdiccas, the Macedonian chiefs condemned Eumenes to death, and charged Antipater and Antigonus with the execution of their order. Eumenes was at first successful, but being defeated through the treachery of one of his officers, he fled to Nora, a strong fortress on the confines of Cappadocia and Lycaonia. Here he made a successful resistance, and was afterwards appointed by Olympias to command the army against Antigonus, whose intentions could no longer be misunderstood. He gained a battle against his adversary, but was unlucky enough to lose the baggage and wives belonging to his Macedonian phalanx. Antigonus offered to restore them on condition that the soldiers would surrender Eumenes into his hands, which they were base enough to agree to; and Antigonus immediately murdered his opponent, in the fortieth year of his age. (Plutarch, *Life of Eumenes*; Nepos; Diodor. Sic. xviii. 30.

Eumenes I. a king of Pergamus, succeeded his uncle Philotærus 263 B. C., and having engaged in hostilities with Antiochus, king of Syria, defeated him near Sardes. But he fell a victim to his habits of drunkenness 241 B. C. and was succeeded by his cousin Attalus. (Strabo, xiii. 624; Athenæus, x. p. 445.)

Eumenes II. eldest son of Attalus I. succeeded to the government of Pergamus on his father's death, 197 B. C., and continued to maintain the intimate alliance which it had been his father's policy to form with the Romans. Antiochus the Great, king of Syria, who at that time secretly meditated contesting the supremacy of the Romans, tried to seduce him by offering one of his daughters in marriage; but Eumenes suspecting the interested intentions of Antiochus, prudently refused the honour of this alliance. In the war which soon afterwards broke out he proved himself the firm friend of the Romans, and assisted Livius Salinator in his victory over the fleet of Antiochus (191 B. C.), on which occasion he was greatly distinguished for his bravery. Again, in the decisive battle which was fought at the foot of Mount Sipylus, in which Antiochus was completely defeated (188 B. C.), the troops of Eumenes greatly distinguished themselves; and on the conclusion of peace this prince received a great addition to his territories at the expense of Antiochus. He was afterwards attacked by Prusias, king of Bithynia, whose forces were under the command of the celebrated Hannibal, and by Pharnaces, king of Pontus; but the powerful mediation of the Romans compelled all parties to lay down their arms. Having become acquainted with the designs of Perseus against the Romans, Eumenes set out for Rome (172 B. C.), to warn the senate of the preparations for war which were making against them. On his return he wished to offer sacrifices to Apollo at Delphi, when he was attacked by a party of assassins stationed by Perseus, and narrowly escaped with his life. He was then carried by his friends to the island of Ægina, where he remained in concealment for some time. A report of his death having reached his brother, the latter assumed the reins of government, and married Stratonice the wife of Eumenes. When he reappeared, this proceeding does not seem to have changed his conduct towards his brother; and they lived in the same amity as before. His close intimacy with the Romans seems to have been broken off towards the end of his reign, and that people endeavoured to embroil him with the neighbouring princes. In this embarrassing state of affairs he died 157 B. C. leaving his throne to his brother Attalus II. (See Sevin, *Recherches sur les Rois de Pergame*, in the *Mémoires de l'Acad. des Inscr.* xii. p. 260.)

Eumenes, a celebrated orator of Athens about the beginning of the fourth century, some of whose harangues and orations are still extant. Also an historical writer in Alexander's army.

EUMENIDES, a name given to the Furies by the ancients. They are fabled to have sprung from the blood of the wound which Cœlus received from his son Saturn; but according to others they were daughters of Earth, and conceived from the blood of Saturn; whilst others again make them daughters of Acheron and Night, or of Pluto and Proserpine. They were three in number, Tisiphone, Megara, and Alecto, to whom some add Nemesis. Plutarch mentions only one called Adrasta, the daughter of Jupiter and Necessity. Supposed to be the ministers of the vengeance of the gods, they were stern and inexorable, and were always employed in punishing the guilty upon earth, as well as in the infernal regions. Upon earth they inflicted the divine vengeance by means of wars, pestilence, and dissensions, and by the secret stings of conscience; in hell they punished the guilty by continual flagellation and torments. They were also called *Furiæ* and *Erinnys.* Their worship was almost universal, and people dared not to mention their names or to look upon their temples. They were honoured with sacrifices and libations; and in Achaia they had a temple, which, when entered by any one guilty of a crime, suddenly deprived him of the use of his reason, and rendered him furious. In sacrifices their votaries used branches of cedar and of alder, hawthorn, saffron, and juniper; and the victims were generally turtle doves and sheep, together with libations of wine and honey. They were usually represented as of grim and frightful aspect, with black and bloody garments, and serpents wreathed round their heads instead of hair. They held a burning torch in one hand, and a whip of scorpions in the other; and were always attended by Terror, Rage, Paleness, and Death. In hell they were seated around Pluto's throne, as the appropriate ministers of his vengeance.

EUMENIDIA, festivals in honour of the Eumenides, called by the Athenians σεμναι θεαι, or venerable goddesses, which were celebrated once every year, with sacrifices of pregnant ewes, offerings of cakes made by the most eminent youths, and libations of honey and wine. At Athens none were admitted but freeborn citizens who had led a life the most virtuous and unsullied.

EUMOLPIDES, the priests of Ceres at the celebration of her festivals at Eleusis. They were descended from Eumolpus, a king of Thrace, who was appointed priest of Ceres by Erechtheus, king of Athens. After his appointment to the priesthood, however, Eumolpus became so powerful that he maintained a war against Erechtheus. The contest proved fatal to both; Erechtheus and Eumolpus were killed; and peace was re-established amongst their descendants, on condition that the priesthood should for ever remain in the house of Eumolpus, and the regal power in that of Erechtheus. The priesthood remained in the family of Eumolpus for twelve hundred years; and this is the more remarkable, because he who was once appointed to the holy office was obliged to observe perpetual celibacy.

EUNAPIUS, a native of Sardis, in Lydia, a celebrated sophist, physician, and historian, who flourished in the fourth century, under the emperors Valentinian, Valens, and Gratian. He wrote the lives of the philosophers and sophists, in which he frequently shows himself a bitter enemy to the Christians; and also a history of the Cæsars, which he brought down from the reign of Claudius, where Herodian ended, to that of Arcadius and Honorius. The history is lost; but its substance has been preserved in Zosimus, who is supposed to have done little more than copy it.

EUNOMIANS, in *Ecclesiastical History*, Christian heretics in the fourth century. They were a branch of the Arians, and took their name from Eunomius, bishop of Cyzicus, who died at a very advanced age, about the year 374, after experiencing a variety of sufferings. The greater part of his works are lost. Besides two or three small pieces, however, there remains a confession of his faith, which Cave has inserted in his *Historia Literaria*, from a manuscript in Archbishop Tennison's library.

EUNUCH, a castrated or emasculated person. Though the practice of castration is detestable in every point of view, yet there appears no real foundation for the injurious opinion generally entertained of eunuchs, that they are all cowards, and devoid of genius for literature or any solid study. It is certain, indeed, that the ancients never supposed eunuchs to be men of inferior intellects, or that they possessed less vigour of mind than other men. It appears from Herodotus that in Persia eunuchs were far from being objects of contempt, and were even frequently promoted to the highest honours. We learn from Agathias, one of the Byzantine historians, that a general in the Roman army named Narses was an eunuch. Aristotle paid such high respect to Hermias, who was an eunuch, and governor of Atarnea, in Mysia, that he even offered sacrifices in honour of him, as Lucian informs us in the dialogue entitled *Eunuchus.*

Eunuchs, in *Ecclesiastical History*, a sect of heretics in the third century, who were mad enough to castrate not only those of their own persuasion, but all others whom they could lay hold of.

EUPATRIDÆ, in *Antiquity*, a name given by Theseus to the nobility of Athens, as distinguished from the Geomori and Demiurgi. By the establishment of Theseus, the Eupatridæ had the right of choosing magistrates, teaching and dispensing the laws, and interpreting religious mysteries. In all other matters the whole city was reduced to an equality. The Geomori were husbandmen, and inferior to the Eupatridæ in point of fortune; the Demiurgi were artificers, and fell short of the Eupatridæ in number.

Eupen
||
Euphrates.

EUPEN, a city of the Prussian province of the Lower Rhine, the capital of a circle of the same name. It is a large scattered place, containing 1500 houses, and between 10,000 and 11,000 inhabitants, who carry on the manufacture of fine woollen cloths and cassimeres to an extent which is unknown in any other part of the same kingdom.

EUPHONY, in *Grammar*, an easiness, smoothness, and elegance of pronunciation. The word is formed from ευ, *bene*, well; and φωνη, *vox*, voice. Quintilian calls *euphonia, vocalitas;* Scaliger, *facilis pronunciatio.*

Euphonia is properly a kind of figure by which we suppress a letter that is too harsh, or convert it into a smoother, contrary to the ordinary rules. Of these there are numerous examples in all languages.

EUPHORBUS, a famous Trojan, son of Panthöus. He was the first who wounded Patroclus, whom Hector killed; but he perished by the hand of Menelaus, who hung his shield in the temple of Juno at Argos. Pythagoras, the founder of the doctrine of the metempsychosis, or transmigration of souls, affirmed that he had once been Euphorbus, and that his soul recollected many exploits which had been done whilst it animated the body of that redoubted Trojan. As a further proof of his assertion, he showed at first sight the shield of Euphorbus in the temple of Juno.

EUPHORION, a son of Polymnestus of Chalcis, a town of Eubœa, born 274 B. C. at the time when the Romans conquered Pyrrhus. He studied under the philosophers Lacydes and Prytanis, and composed many works both in prose and verse. He was appointed by Antiochus the Great, king of Syria, to superintend the library he was collecting at Antioch, which he was anxious should rival that at Alexandria; and here Euphorion resided till his death. Only a few fragments of his works have been preserved; but from the opinions expressed by ancient writers we find that the erudite character of his allusions rendered him so obscure that he was difficult to be understood, and that he was constantly in search of rare and obsolete expressions. Yet he was much admired in the time of Cicero; and in the reign of Augustus his works still continued to be favourites. Cornelius Gallus translated some of his poems; but it was the Emperor Tiberius who carried his admiration beyond all bounds. He imitated his style, as well as that of Rhiarius and Parthenius, and placed their books and busts in all the public libraries. See an account of his life and character by Meinecke, prefixed to an edition of his fragments; *De Euphorionis Chalcidensis Vita et Scriptis*, &c. Gedani, 1823; also Clinton's *Fasti Hellenici*, vol. ii. p. 511; Heyne, *De Euphorione, et Excurs.* iii. *ad Virg. Eclog.* vi. 64, and *Excurs.* v. *ad Æn.* ii. See also *Ephemer. Liter.* Halens. 1824.

EUPHRATES, a large river of Asia, taking its origin from several sources in the great range of Mount Taurus. There are two branches in particular which dispute the honour of being the principal. One to the east, called Mured, rising not far from the town of Bayazid, traverses the southern part of Armenia Proper; the other, to the west, called by the inhabitants Frat, is formed under the walls of Erzeroum by the junction of two small rivers. The Frat and Mured unite their waters a little below the town of Arabkir, when the river descends rapidly towards the defile called the Pass of Nashar. It then winds along an elevated plain, and about twenty-two miles above Samosat, the ancient Samosata, forms a double cataract. Having now cleared all the obstacles that opposed its progress, it rolls majestically along through a wide and verdant valley. At Korna, about a hundred and thirty miles from its mouth, it is joined by the Tigris, and forms with it the Shet-al-Arab, or river of Arabia, one of the noblest rivers in the east. At this point the land sinks, and is occupied with meadows and morasses; but even in the driest season it is navigable for boats of considerable burden as far as Skukashu, a village about a day's sail farther up. Above this point the tides of the Persian Gulf reach twenty or twenty-five miles, and the river is navigated during six months of the year by flat-bottomed boats as far as Hibah. The Euphrates has three principal mouths; but bars of sand formed by the river, and which change in their form and situation, render the approach very dangerous. It is said that the tide, meeting with violence the downward course of the stream, divides its waters in the form of frothy billows. The course of the Euphrates before joining the Tigris is about 1400 miles; and adding a hundred and thirty miles for the distance from its junction with the Tigris to the sea, its whole course will be upwards of 1500 miles. Its greatest increase is in January, when it rises twelve perpendicular feet, in consequence principally of the melting of the snows on the Taurian range. Taking advantage of this circumstance, the ancient inhabitants of Asia Minor formed numerous artificial canals and lakes, for the double purpose of protecting the contiguous plains from inundation, and of preserving the superfluous waters for irrigation. The canal of Pallacopus, which was dug by the Babylonian kings, is one of these; and the Sea of Nejiff was also a gigantic work. In general, however, the country languishes under the wretched policy of the Turks; and these great works of art for protecting it against the overflowing streams, and at the same time for preserving the water for fertilising the soil, have fallen into neglect and disrepair. In the time of Alexander, the Tigris and Euphrates entered the sea by separate mouths. (Mannert, *Geographie von Indien*, vol. ii. p. 143; D'Anville, *Euphrates;* Niebuhr, *Voyage*, vol. ii. p. 228, 253, 261. See also Malte Brun, and an able memoir on the Euphrates in the *Journal of the Royal Geographical Society*, vol. iii. Lond. 1834.)

E lis
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EUPOLIS, a poet of Athens, born about 446 B.C., was one of the writers of the old comedy. He began to exhibit his plays at the early age of seventeen, and contended with Aristophanes for the prize 425 B. C. It is said that seven of his pieces were crowned with victory. In those days when the law of libel had not yet been invented, the great and powerful took very summary vengeance on those who had spoken disrespectfully of their characters. Thus Alcibiades is reported to have inflicted a punishment on Eupolis, which was utterly unworthy of his high name. It appears that Eupolis was a private soldier in the army commanded by Alcibiades; and in the voyage to Sicily that general ordered him to be lashed to a rope and plunged several times into the sea, in order to teach him, as he said, to speak with less freedom of his superiors (*Cic. Att.* vi. 1.). Eupolis perished in a battle against the Lacedæmonians, and it was in consequence of this disastrous defeat that the decree was passed by the Athenians to exclude poets from military service. The fragments of his works have been collected. (*Eupolidis Fragmenta, Gr. Lat. et cum Notis edid.* Rob. Walpole, 1805; *collegit Mart. Runkel*, 1829. See Meinecke, *De Eupolidi, veteris Comœdiæ Poeta*, Berlin, 1826; also Lucas, *Cratinus et Eupolis*, Bonn, 1826.)

EURE, a department of the north-east of France, formed out of the ancient Norman Bexin, the district of Saint André, Neuburg, a part of Perche, and of Ouche, Auge, Lienvin, and Roumois, all parts of the former country of Normandy. It is bounded on the north by the department of the Lower Seine, on the east by those of Oise and Seine-Oise, on the south by Eure-Loire and Orne, and on the west by Calvados. The extent is 2420 square miles, or, according to the *Almanach Royal*, 623,283 hectares, of which 371,136 are arable land, 108,000 woods, 11,931 vineyards, 18,537 meadows, 2726 gardens, 47,581 uncultivated land, and the remainder roads, rivers, and the sites of towns. It is divided into five arrondissements, thirty-six cantons, and 843 communes, inhabited by 421,480 persons. It is generally a level country, but a few hills are to be seen on the borders of the Seine, the Rille, and the Eure, though none of them are more than three hundred feet above the level of the sea. The soil generally consists of vegetable matter, mingled with clay and sometimes marl, resting on a bed of chalk or stone. The cultivation is tolerably conducted; so that, with the natural fertility of the soil, the department, though rather densely peopled, produces more corn than the population requires. The chief kind of corn is wheat, the growth of which occupies a larger space than rye, oats, and barley together. Flax is largely cultivated, and, from its length, fineness, and colour, is highly esteemed. The seed of this plant is drawn either from Flanders or from Riga. Some hemp is also produced. The horses of the department, of the pure Norman breed, have always been celebrated, and, though they had nearly lost their high character, have of late been more carefully bred and much improved. The breed of cows is remarkably good; and the calves are much in request in the neighbouring departments. Sheep have been neglected, but have recently increased; and those on the coast, known as *Moutons du Pré Salé*, are highly valued for their excellent meat. Of late years attempts have been made to improve the wool by a mixture of merinos. Fruit is very abundant, especially apples, from which much cider is made. The wine is but of moderate quality, and will rarely bear to be kept longer than three years. There are no mines but of iron, which yield annually 400 tons.

This department is a manufacturing part of France; and cotton, linen, and woollen cloths of every kind, are fabricated. There are large establishments for making copper ware of all kinds, the various descriptions of paper, nails, pins, and needles, glass for windows, and glass bottles, and jewellery and trinkets. These employments occupy the larger portion of the inhabitants. Such goods form the trade; in addition to which, fire-wood, timber, cattle, honey, wax, and corn, are furnished to the districts surrounding the department.

EURE AND LOIRE, a department of the north-west of France, formed out of parts of the ancient Orleannois, and a portion of the duchy of Maine. It is bounded on the north by the department of the Eure, on the east by that of Seine-Oise, on the south by those of Loiret and Loire-Cher, and on the west by those of Sarthe and Orne. Its extent is 2420 square miles, or, according to the *Almanach Royal*, 602,752 hectares. The civil divisions are four arrondissements, twenty-four cantons, and 460 communes, containing 265,943 inhabitants. The face of the country is level in general, with a few hills, none rising to a greater height than 500 feet. The soil in the middle and west of the department is the best. It consists, for the most part, of thick layers of grey, yellow, or black clay, intermixed with sand, or of calcareous earth, and is on the whole fertile, but in the south-west, especially in the arrondissement of Nogent, it is sandy and dry, and many tracts of land are so poor as to be uncultivated. None of the rivers of this department, even those from which it is named, are navigable till they have left it. The agriculture is better conducted than in most of the departments of France; and the production of the various kinds of corn so far exceeds the consumption, that nearly 200,000 quarters are annually exported to the other parts of the kingdom. The wheat is remarkably fine, and is prized on account of its being easily preserved for a long time, and best adapted for sea voyages. The cows are small, but yield good butter for the supply of Paris, and fat oxen and calves for the markets of Poissy and Sceaux. The sheep are numerous, but not remarkable, except some flocks whose wool has been improved by crosses with the merino races. Wine is not extensively produced, nor of the best quality; but in some parts there is an abundant supply of apples, from which cedar is made as the common drink of the inhabitants. There are no mines but of iron, and these yield about 1200 tons annually, which is not more than one third of the demand. The manufactures are not extensive; but leather, paper, cotton goods of various kinds, serges, flannels, and other coarse woollens, hosiery, hats, caps, household linen, such as sheetings and table linen, and some earthenware, are furnished. The department draws its supply of fuel from its own woods, which cover about one twelfth part of the whole surface.

EURIPIDES, the son of Mnesarchus, a celebrated tragic poet, was born 480 B. C. in the island of Salamis, to which place his parents had been obliged to fly from Athens at the time it was threatened by the invasion of Xerxes. His birth took place on the very day that the battle was fought near the strait Euripus, the prelude to the more decisive engagement in the vicinity of Salamis. To commemorate this event, the embryo poet was called Euripides. As of every illustrious man, there are some stories told which predicted his future destiny, and, amongst these, an oracle declared that he should be crowned at the Olympic games. His father, misunderstanding its true meaning, trained him for athletic exercises, and it appears that he was victorious at the games celebrated in honour of Theseus and Ceres. But fate had destined him for a higher and a more ennobling occupation; he began to devote himself to the study of eloquence under Prodicus of Chios, and to take lessons from the philosopher Anaxagoras. It is said by some that he was a disciple of Socrates, but we can scarcely credit this statement, as the philosopher was thirteen years younger than the poet. The persecutions which Anaxagoras underwent from the bigotry of the Athenians clearly demonstrated to Euripides the dangerous path which he was pursuing, and induced him to renounce the study of philosophy, and direct his attention to the stage. This took place, it is said, in his eighteenth year, and in 455 B. C. he succeeded in gaining the third prize. Of all the plays which he wrote, only five, according to Varro, were reckoned worthy of being crowned; but this fact may be explained by the violent spirit of rivalry and jealousy which seems to have prevailed at Athens at this time. In his domestic affairs he was by no means fortunate; both his wives disgraced him by the irregularity of their lives; and from this circumstance probably arose his violent hatred of the sex, the weakness of which he took every opportunity of ridiculing and exposing. His private grief became the butt of the comic writers of the day, and Aristophanes more particularly held him up to the ridicule of the public. It was no doubt in consequence of these incessant attacks that Euripides determined to retire to the court of Archelaus, king of Macedonia, who reigned from 413 to 339 B. C., and was then the beneficent patron of literature and science. By him he was received with all that respect to which his distinguished talents entitled him, and some say that he was appointed one of his principal ministers. Here he resided till his death (406 B. C.), which was as full of tragic circumstances as any story ever exhibited upon the stage. As he was strolling through a wood, a pack of the royal hounds attacked the poet, and tore him in pieces. His remains were removed to Pella by the king, and every honour was shown to his memory. The Athenians were now anxious to procure his ashes, but Archelaus refused to gratify those who had neglected the poet in his lifetime.

It is difficult to convey an exact idea of the character of Euripides as a dramatist to those who have not read the original. His language is raised but little above that of common conversation, yet he possesses the rare art of choosing his words so well, that the most common are ennobled by their happy combination. He has none of the dithryambic boldness of Æschylus, none of the pompous magnificence of Sophocles, yet he touches the hidden springs of human passion with a masterly hand. Still he is full of faults, which the good taste of all ages must condemn. He is too fond of learned digressions, "of wise saws" and philosophical maxims; and the plots of his plays are not always so clear and unembarrassed as they ought to be. Of eighty-four tragedies, of which Barnes has given a list, only nineteen have been preserved. They are, *Hecuba, Orestes, Phœnissæ, Medea, Hippolytus, Alcestes, Andromache, Supplices, Iphigenia in Aulis, Iphigenia in Tauris, Rhesus, Troades, Bacchæ, Cyclopæ, Heraclidæ, Helena, Ion, Hercules Furens, Electra.*

There are numerous editions of his works. But we believe that of Barnes, Cambridge, 1694, fol. and that of Matthiæ, Leipsic, 1813–1829, vol. ix. to be the best.

EUROCLYDON, (from Ευρος, *the east wind*, and κλυδων, *a wave*), is a species of wind, of which we have an account only in the Acts of the Apostles (xxvii. 14), and concerning the nature of which critics have been much divided. Bochart, Grotius, Bentley, and others, substitute another reading, supported by the Alexandrian Manuscript, and the Vulgate, namely, Ευρακυλων or *Euro-aquilo;* but Mr Bryant defends the common reading, and considers the *Euroclydon* as an east wind which causes a deep sea or vast inundation. He maintains, in opposition to the reasoning of Bentley, who supposes that the mariners in the ship, the voyage of which is recited in this passage, were Romans, that they were Greeks of Alexandria, and that the ship was an Alexandrian ship employed in carrying corn to Italy; and, therefore, that the mariners had a name in their own language for the particular typhonic or stormy wind here mentioned. He also shows from the passage itself, that the tempestuous wind called *Euroclydon* beat upon the island of Crete; and hence, as this is a relative expression, referring to the situation of the person using it, who was at that time to the windward or south of it, the wind blew upon shore, and must have come from the south or south-east, which, he adds, is fully warranted by the point where the ship was, and the direction it ran in afterwards, which was towards the north and north-west.

EUROPA, in fabulous history, a daughter of Agenor, king of Phœnicia and Telephassa. She was so beautiful that Jupiter became enamoured of her; and, in order to seduce her, he assumed the shape of a bull, and mingled with the herds of Agenor, whilst Europa, with her female attendants, were gathering flowers in the meadows. Europa caressed the beautiful animal, and at last had the courage to sit upon his back. The god took advantage of her situation, and with precipitate steps retired towards the shore, crossed the sea with Europa on his back, and arrived safe in the island of Crete. Here he assumed his original shape, and declared his love. The nymph consented, though she had once made vows of perpetual celibacy, and became mother of Minos, Sarpedon, and Rhadamanthus. After this amour with the king of the gods, Europa married Asterius, king of Crete. This monarch, seeing himself without children by Europa, adopted the fruit of her loves with Jupiter, and always esteemed Minos, Sarpedon, and Rhadamanthus, as his own children. Some suppose that Europa lived about 1552 years before the Christian era.

EUROPE,

Comparative advantages and disadvantages of this division of the globe.

ONE of the great divisions of the globe. On a first view Europe appears to be less favoured by nature than the other quarters of the globe over which it has obtained so great an ascendancy. It is much smaller in extent; its rocky and mountainous surface does not admit of those noble rivers, like inland seas, which lay open the remotest regions of Asia and of America to the commerce of the world. Its vegetable productions are neither so various nor so exuberant; and it is poorly supplied with the precious metals, and with many of those commodities on which mankind set the greatest value. On the other hand, the climate of Europe, if it nourishes a less luxuriant vegetation, is of an equal and temperate kind, well adapted to preserve the human frame in that state of health and vigour which fits it for labour, and promotes the developement of the intellectual and moral powers. The mountains that intersect its surface are barriers which enabled infant communities to protect themselves from violence, and to lay the foundation of arts, knowledge, and civilization. If it has few large navigable rivers, its inland seas and bays are, from their position and extent, the finest in the world, and have been the means of creating and nourishing that commercial spirit which has been one great source of its improvement. Though comparatively deficient in gold and silver, it is abundantly supplied with those useful metals and minerals which minister still more essentially to the wants of civilized life. Its apparent defects have become the source of real benefits, and the foundation of its grandeur. The disadvantages of its soil and climate have excited the industry of its inhabitants, given them clearer ideas of property, kindled a resolute spirit to defend their rights, and called into existence that skill and enterprise, and those innumerable arts and inventions, which have enabled the inhabitants of this apparently barren and rocky promontory to command the riches and luxuries of all the most favoured regions of the globe. It is only in Europe that knowledge and the arts seem to be indigenous. Though they have appeared at times among some of the nations of Asia, they have either stopt short after advancing a few steps, or they have speedily retrograded and perished, like something foreign to the genius of the people. In Europe, on the contrary, they have sprung up at distant periods, and in a variety of situations; they have risen spontaneously and rapidly, and declined slowly; and when they disappeared, it was evident they were but crushed for the time by external violence, to rise again when the pressure had subsided. It is only in Europe, and among colonies of Europeans, that the powers of the human mind, breaking through the slavish attachment to ancient usages and institutions, have developed that principle of progressive improvement, of which it is impossible to calculate the final results. The rudest tribe in Europe, in which this principle has taken root, has a certain source of superiority over the most improved nations of Asia and Africa, where society remains perfectly stationary. If these nations are ever destined to advance in civilization, they must borrow from Europe those arts which she has invented, and which belong to civilized life in every climate. But the tenacious adherence of rude nations to the customs and superstitions of their ancestors, will not allow us to hope that the benefits of civilization will be rapidly diffused in this way. It is more probable that colonies from the older states of Europe will multiply, as the population becomes more and more redundant; and that these colonies will carry the arts and knowledge, the language and manners of Europe with them, to the other quarters of the world. From prejudices on both sides, it is found that two races, in very different stages of civilization, do not readily amalgamate; and it is therefore probable, that the feebler inhabitants of these countries, like the American Indians, will be gradually displaced by the continual encroachments of the more energetic race of Europe. Such a change, however, must take place slowly, and there is nothing in it to alarm humanity. The vast number of tribes that people Asia and Africa seem born only to be the victims of savage superstition and ferocious tyranny. No treatment they are likely to experience from European colonies can render their condition worse; and were the whole swarm of these nations to die out in the course of nature without being renewed, no great deduction would be made from the sum of human enjoyment. Should the state of things we have been contemplating, and which seems to arise naturally out of the circumstances of Europe and the other quarters of the globe, be realized, it will be curious to reflect on the circle of changes which will then be completed. The ancient inhabitants of Europe, as well as the modern, were originally colonies sent off from the surplus population of Asia. Here they have thrown off their barbarism, invented and improved arts and sciences, and carried their social institutions to a high degree of perfection; and now, in the maturity of their strength, they are throwing back their surplus numbers upon Asia, to conquer and supplant the remains of those tribes from which they originally sprung.

Bounda- ies and xtent.

Europe is bounded on the north and west by the Arctic and Atlantic Oceans; on the south by the Mediterranean, the Black Sea, and Mount Caucasus; on the east by the Caspian Sea, the river Ural, and the Uralian Mountains. These are the limits proposed by Malte Brun, and adopted by Balbi and other recent geographers, as corresponding better with the natural divisions of the earth's surface than the old boundary, which on the east side passed from the Sea of Asoph to the Uralian Mountains, by the courses of the Don, the Wolga, and the Kama. The greatest length of the continent of Europe is from Cape St Vincent to the Sea of Kara, in the direction of north-east and south-west, and is 3490 English miles. Its greatest extent from north to south is from Cape Matapan to Cape North, 2420 miles. The superficies of Europe, including the Azores, Iceland, Nova Zembla, and all the other islands belonging to it, is 3,700,000 English, or 2,800,000 geographical square miles.

limate.

The climate of Europe is distinguished by two peculiarities. It enjoys a higher mean temperature than any of the other great divisions of the world in the corresponding latitudes; and it is not subject to such violent extremes of heat and cold. These advantages it owes chiefly to its numerous seas, inland bays, and lakes, which render its temperature similar to that of islands; and partly also, according to Humboldt, to its situation at the western extremity of the greatest range of dry land on the surface of the globe; the western sides of all continents being warmer than the eastern. Europe lies almost entirely within the temperate zone, not more than one fourteenth part of its surface being within the arctic circle. Only a very small part of it is uninhabitable from cold, and it nowhere suffers much from excessive heat. The mean temperature at its southern extremity, in the latitude of 36°, is about 66° of Fahrenheit; and at Cape North, in the latitude of 71°, where the mean temperature is 32°, the cold is not greater than in the latitudes of 55° or 56° on the east coasts of Asia and America. Hence Europe is habitable at a higher latitude by 12° or 14° than either of these continents. The following table, taken from Humboldt's *Memoir on the Distribution of Heat* (abridged in Dr Thomson's *Annals of Philosophy*, xi. 188), shows the difference in temperature between Europe and the eastern shores of Asia and America at the parallel of 40°; the difference is much greater at the parallel of 60°.

	Lat.	Mean Temperature		
		of the Year.	of Three Winter Months.	of Three Summer Months.
Rome..........	41·35	60·4	45·8	75·2
Pekin..........	39·54	55·2	26·8	82·6
New York......	40·40	53·8	29·8	79·2

There is a difference of the same kind between the temperature of the sea-coasts of Europe and the interior. In islands, and on the sea-coast, the mean temperature of the year is higher, and the heat is more equally distributed through the different seasons. As we advance from the coast eastward the mean annual temperature diminishes, but the heat of summer and the cold of winter increase. Thus London has the same mean annual temperature as Vienna, but it has the summer of Petersburg, and the winter is warmer than at Milan. The Mediterranean, the Baltic, and inland lakes, produce the same effect as the ocean, in an inferior degree. The two following tables are taken from Humboldt (*Annals of Phil.* xi. 188): the first shows the temperature of the year, and the various seasons in places having the same latitude; the second shows the different distribution of heat through the various seasons in places having the same mean annual temperature.

PLACES.	Mean Temperature						
	of the Year.	Winter.	Spring.	Summer.	Autumn.	Warmest Month.	Coldest Month.
I. *Lat.* 56.							
Edinburgh[1].......	47·8	38·6	46·4	58·2	48·4	59·4	38·3
Copenhagen.....	45·6	30·8	41·2	62·6	48·4	65·0	27·2
Moscow..........	40·2	10·8	44·0	67·1	38·3	70·6	6·0
Lat. 48........							
St Malo..........	54·4	44·2	52·2	66·0	55·8	67·0	41·8
Vienna...........	50·6	32·8	51·2	69·2	50·6	70·6	26·6
II. *Lat.*							
Dublin, 53·21	49·2	39·2	47·3	59·6	50·0	...	...
Prague, 50·5	49·4	31·4	47·6	68·9	50·2	...	...

Mountains.

The mountains of Europe are more numerous in proportion to its extent than those of the other great continents, but they are of less elevation than the mountains of America and Asia. The highest and the most extensive chains in Europe run generally in the direction of east and west, and are placed near its southern shores. The central mass of the Alps, with which all the other mountains in the south of Europe are connected, forms the summit of the continent, and determines the position of the surface and the course of most of the rivers. From this central point the surface of the land descends to the sea by a series of valleys, skirted by subordinate chains. The three countries to the southward of the Alps and their branches, Greece, Italy, and Spain, consist of mountainous peninsulas projecting into the Mediterranean. The countries to the west, north, and east of the Alps, which present more extensive plains and gentle declivities, are the seats of the three principal monarchies in the south of Europe. Austria, seated on the eastern declivity, rules over the countries watered by the Danube; France occupies the western declivity, and the countries watered by the principal streams that flow to the west; and Prussia the countries watered by the streams that flow to the north. If we descend from the Alps to the sea in a western direction, the first valley we meet with is the level part of Switzerland, between the Alps and Mount Jura, elevated from 1600 to 1800 feet above the sea: the second, between Jura and the Cevennes, some hundred feet lower; and the third, and lowest, extends from the Cevennes to the Atlantic. In a north and north-east direction, the first valley is Bavaria, the second Bohemia, both of which are completely inclosed by mountains; the third, consisting of Silesia, Brandenburg, and Poland, terminates in the Baltic. In an eastern direction the first valley is Austria, the second Hungary, both encircled with mountains; the third, Bulgaria, extends to the Black Sea. South from the Alps we have first the valley of Lombardy, and then the narrow coast of Genoa. The vast plain occupied by Russia and the eastern part of the Swedish peninsula may be considered as a prolongation of the valley of Prussia and Poland, extending to the Dofrines on the west, the Uralians on the east, and Mount Caucasus on the south. Thus, in a general point of view, the elevation and declivity of the large plains of southern Europe bear a certain relation to the position and distance of the central mass of the Alps.

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[1] Copenhagen is about 620 miles east from Edinburgh: Moscow about 1000 miles farther.

Alps.

The principal mass of the Alps extends in a semicircle from Nice, on the shores of the Mediterranean, to Trieste, on the Adriatic, a distance of 550 miles. Southward of Mont Blanc, the Alps consist of a single chain, with many lateral branches, which lie chiefly on the west side; but immediately to the eastward of Mont Blanc, the principal chain divides into two, which inclose the sources of the Rhone. These meet, again, at St Gothard, and, on the east side of it, part into three chains, one of which loses itself in Bavaria, another in Austria near Vienna, and the third terminates near Trieste. A lateral chain, of no great elevation, passes eastward, and connects the Alps with the mountains of European Turkey. Smaller branches connect the Alps with the Bohemian and Carpathian Mountains on the north, with the Vosges and Cevennes on the west, and, through the latter, with the Pyrenees. The Appennines are but a prolongation of the Alps on the south. Mont Blanc, the loftiest of the Alps, and the highest mountain in Europe, has an elevation of 15,680 English feet; and Mount Rosa, the Jungfrau, the Schreikhorn, and several other summits, approach to this height. The elevation of the chain diminishes towards both extremities. In general, the escarpments, or steepest sides, are turned towards Italy, and the lateral and subordinate branches are most numerous, and extend farthest, on the opposite side. The central chain of the Alps consists chiefly of granite, gneiss, sienite, and other primitive rocks. Among the lateral ridges, to the westward of St Gothard, calcareous rocks, with clay-slate and mica-slate, abound on the side of France; on the side of Italy the ridges are narrower, magnesian rocks abound, and the clay-slate is wanting. On both sides are found great deposits of gravel, and large detached blocks or boulders, often at a vast distance from their original situations. Eastward from St Gothard, the central chain is accompanied on each side by a calcareous chain of great elevation. Though the summits of the Alps are steep and rocky, and the higher valleys are filled with glaciers, there is much good soil below. The vine grows to the height of 1600 feet above the sea, the oak to the height of 3390, corn to 4200 feet, and the larch to 6720 feet. At 6400 feet above the sea, we have the climate of Lapland in latitude 68°, so that a degree of latitude in the northern half of the temperate zone in Europe corresponds to an elevation of about 290 feet. The inferior limit of perpetual snow, according to Humboldt, is at the height of 8760 feet, in the latitude of 46°. (Humboldt *De Distributione Geographica Plantarum*, Paris, 1817, p. 122–165).

The chain of the Pyrenees, which is next to the Alps in elevation, runs in the direction of east and west. Its length is about 240 miles; but, if we include the Cantabrian Mountains, which continue in the same line without interruption, the whole length will be about 500 miles. The central chain of the proper Pyrenees is of granite, but the most elevated summits are of secondary limestone, and lie on the south side of the granite. Mont Perdu, esteemed the loftiest of the whole range, consists of fetid limestone, and rises to the height of 11,270 feet. The south side of the Pyrenees is rugged and precipitous; but on the north there is a gradual descent to the plains of France by a series of parallel ridges diminishing in height. The Cantabrian Mountains are lower than the Pyrenees, and present their steepest sides to the north. There are four other chains of mountains in Spain, all running in a direction approaching to east and west, and all connected with one another and with the Pyrenees. The most elevated of these is the Sierra Nevada, the southmost, one of whose summits rises to the height of 11,660 feet. (*Laborde*, i. 173). The inferior limit of perpetual snow on the Pyrenees is at the height of 8960 feet. The red pine rises to the height of 7480 feet, which is about 700 feet higher than any species of trees on the Alps.

The Appennines form an uninterrupted chain 750 miles in length, extending from the south-west termination of the Alps near Nice to the Straits of Messina. The north-west division, which skirts the basin of Lombardy, consists chiefly of greywacké; from Tuscany to near the southern extremity, the prevailing rock is secondary limestone. Granite and other primitive rocks are found at the two extremities in Liguria and Calabria, but are wholly wanting in the intermediate space. The most considerable elevations are about the middle of the chain, where Il Gransasso rises to the height of 9570 feet.

The Carpathian and Sudetic Mountains, with the Erzgebirge and Boehmerwald, may be considered as forming one continued chain, the length of which, from the point where it strikes the Danube in Hungary, to the point where it strikes the same river in Bavaria, is about 1200 miles, exclusive of the transverse branches which separate Moravia from Bohemia and Hungary. The declivities of this long range of mountains are steepest on the south side. The elevations are lowest on the west, and generally increase as we advance eastward, till we come to the sources of the Thiess in the north of Hungary, after which they again decline. The Fichtelberg, at the westmost point of the chain, is 4030 feet high: Schnekoppe, the highest of the Sudetic Mountains, is 5280 feet, and Lomnitz in Hungary, the loftiest of the whole range, is 8460 feet. None of these mountains rise to the region of perpetual snow, the inferior limit of which, according to Wahlenberg, is about sixty feet above the summit of Lomnitz. The most elevated parts of these mountains consist of primitive rocks; corn and fruit trees are said to grow at a greater height upon the Carpathian's than upon the Alps, though the latter are two degrees farther south.

D nes.

The chain of the Dofrines, or great Scandinavian Alps, is about 1000 miles in length, and has a general elevation of from 6000 to 6500 feet. The altitude of Skagstlos Find, the highest mountain of the chain, is 8400 feet. These mountains consist almost entirely of primitive rocks, and present their steepest sides to the west. On Sulitelma, the highest mountain of this chain in Lapland, in latitude 67·10, the inferior limit of perpetual snow is at the height of 3500 feet.

U s.

The Uralian Mountains, which form the boundary of Europe on the north-east, are but imperfectly known. Some of their summits are covered with perpetual snow, but their height is believed not to exceed that of the Scandinavian Alps. They consist chiefly of primitive rocks. The whole length of the chain, which runs nearly north and south, is about 1400 miles.

M tains
of rkey.

Of the mountains of European Turkey we know as little as of the Uralian chain. From a central point, nearly equidistant from the Danube, the Adriatic, and the Ægean Sea, three chains proceed in different directions; one, the ancient Hemus, runs eastward to the Black Sea; a second, north-westward, till it joins the Carnic Alps; and a third, southward, through the peninsula of Greece. These principal chains send out many branches, but neither their height nor their geological structure is known with any degree of accuracy.

Ce nes.

The Cevennes in the south of France extend about 300 miles in length from north to south, and their two most elevated summits, Mont d'Or and Cantal, rise to the height of 6400 and 6170 feet. Mount Jura, between France and Switzerland, has nearly the same elevation. The Vosges, a small chain in the north-east of France, rise nowhere more than 4600 feet above the sea.

M tains
of tain.

The mountains of Britain extend, with some interruptions, over a space of 630 miles, along the west side of the island. They are not placed in chains, but rather in irregular groups, and consist chiefly of primitive and transition rocks. Snowden in Caernarvonshire, the highest mountain in Wales, has an elevation of 3570 feet. Bennevis in Inverness-shire, which rises 4336 feet above the sea, is the highest land in the island.

Vo noes.

There are thirteen volcanoes in Europe, all situated in the vicinity of the sea, and of which the following are the most remarkable: Mount Ætna, in Sicily, is 10,940 feet in height. Its eruptions happen very irregularly; sometimes fifty or a hundred years have intervened between one eruption and another; at other times less than one year. Mount Vesuvius, near Naples, which lies about two hundred miles north from Ætna, is 3820 feet high. Its eruptions are less frequent than those of Ætna. Stromboli, which occupies an island in the Mediterranean, about eighty miles north from Ætna, is the only volcano in Europe that throws out smoke or flames constantly. Heckla, near the south coast of Iceland, is 4980 feet high. Its eruptions are not frequent. The last was in 1783.

Riv

Europe is well watered with rivers, but they are but brooks compared with the mighty streams of Asia and America, and, from the unevenness of the surface, afford in general no great extent of inland navigation. The Danube, the largest river that is entirely in Europe, is about 1500 miles in length, and waters a superficies of 370,000 square miles. But the Amazons, though only twice the length of the Danube, waters a surface seven times as large, and equal to four fifths of the continent of Europe; and, as the quantity of rain that falls in tropical countries is much greater than in northern latitudes, it is probable, notwithstanding the increased evaporation there, that the Amazons conveys more water than all the rivers of Europe put together. If we divide the length of the Danube into a hundred parts, the length of the principal rivers of Europe, expressed in these parts, will be as follows:

Danube	100
Wolga	130
Dnieper	72
Don	69
Rhine	49
Elbe	42
Vistula	41
Loire	37
Tagus	32
Oder	31
Rhone	30
Seine	23
Po	21
Tiber	10
Thames	9

A much smaller proportion of the waters of the European continent flows into the Mediterranean than the extent of its coasts would lead us to expect. The high mountains that range along the south of Europe, parallel to its shores, from Gibraltar to Constantinople, turn the course of the large streams in an opposite direction. Though the length of the line of coast between the points last mentioned, without computing minute sinuosities, is 4000 miles, or one fourth of the circumference of Europe, not more than one tenth of the waters of this quarter of the globe fall into the Mediterranean. The Black Sea, on the other hand, which presents only 850 miles of coast on the side of Europe, receives one fourth of its waters. It will be seen from the subjoined table that one tenth part of the waters of Europe flows into the Caspian by the Wolga; that the Black Sea and the Baltic alone receive one half, whilst only about one sixth falls into the Atlantic. If the whole of the river waters of Europe be divided into a hundred parts, their distribution will be nearly as follows:

	Length of Coast in Miles.	Water conveyed by Rivers in parts.
Whole length of the bounding line of Europe, and whole quantity of water	16,000	100
Mediterranean, from Gibraltar to Constantinople	4000	10
Black Sea and Sea of Asoph	950	26
The Baltic to the Naze of Norway	3340	25
The Atlantic, from Gibraltar to Cape North	3640	17
The Arctic Ocean, from Cape North to the Sea of Kara	2200	12
The Caspian Sea (in Asia)	......	10

We are not acquainted with the height of the sources of many of the European rivers above the sea. Those of the Danube, according to Malte Brun, are from 2100 to 2200 English feet, which gives a fall of one foot and a half per mile, but near the sea the inclination is less; for at Buda, 900 miles from the mouth of the river, its height, according to Wahlenberg, is 229 feet, which gives a fall of three inches per mile for the lower part of its course. It begins to be navigable at Ulm. In general the rivers

Europe.

of Russia, Poland, and the north of Germany, flow over a more level surface, and are more navigable, than those of the south of Europe. Professor Robison states, on the authority of the Abbé Chappe, that the sources of the Wolga are but 480 feet above the ocean (*Encyc. Brit.* article RIVER); but as the Caspian Sea, in which this river terminates, is found to be 324 feet below the Black Sea, this increases the space through which the waters of the Wolga descend to 804 feet, in a course of 2000 miles. The average fall may therefore be about two inches and a half per mile.

Islands.

The islands of Europe, including Nova Zembla and Iceland, occupy a space equal to 280,000 square miles, or one eleventh part of the surface of the continent; and of this space the area of the British isles amounts to rather less than one half. The Black Sea is the only large sea connected with Europe in which there are no islands worthy of notice.

Inland seas. Mediterranean.

The Mediterranean, the noblest inland sea in the world, forms the southern boundary of Europe, separating it from Africa, and partly also from Asia. It may be considered as the bottom of a vast basin formed by the Pyrenees, Alps, Mount Hemus, Taurus, Libanus, and Atlas. These mountains are everywhere near its shores, which are consequently narrow and much inclined. Hence there are no such extensive plains as Hungary or Poland near the coast of this sea, and hence also no very large rivers fall into it except the Nile; and altogether it receives a smaller quantity of water from rivers than the Black Sea or the Baltic, though six times larger than either. Its length is about 2350 miles, its breadth is extremely various, and its surface (exclusive of the Black Sea) is nearly equal to 1,000,000 of square English miles, or something less than a third part of the continent of Europe. It is generally of great depth, and its numerous islands, which have uniformly a rocky surface, appear to be the summits of marine mountains.

Baltic.

The Baltic, the greatest inland sea that is entirely in Europe, is about 1200 miles long, of very unequal breadth, and presents a surface of 175,000 square miles, exclusive of islands. It occupies the bottom of another large basin, 850 miles in breadth, and 1400 in length, extending from the Norwegian mountains on the north and west, to the Carpathians on the south, and to the high lands in which the Dnieper, Don, and Wolga rise, on the east. This basin, equal to one third of the surface of Europe, has a very different character from that of the Mediterranean. The mountains are not very elevated, and are so placed as to leave a large tract of land very little inclined between them and the Baltic, over which, especially on the south side, many considerable rivers flow with a gentle current. Hence the country round the Baltic is much more level than round the Mediterranean; lakes are numerous in the low grounds, from the want of declivity; the sea itself is comparatively shallow, and, receiving a much greater quantity of river water, it is much inferior in saltness. The commerce of the Baltic is annually interrupted by the ice, which endures four months in the Gulfs of Bothnia and Finland. The whole of this inland sea has sometimes been frozen over for a short time, but this is of rare occurrence.

Black Sea.

The Black Sea, which belongs only partly to Europe, is 690 miles long and 360 miles broad, and, including the Sea of Asoph, presents a surface of 170,000 square miles, being almost of the same magnitude as the Baltic. It derives four fifths of its water from Europe, and is curiously distinguished from the other seas of this quarter of the globe, by its being almost totally destitute of islands.

The White Sea is 450 miles in length, of a very irregular figure, and occupies a space equal to 35,000 square miles. It receives some considerable rivers, but is frozen during six months of the year.

The lakes of Europe are numerous, and are of two kinds; those which lie in cavities at the foot of high mountains, and which are generally deep, such as the lakes in the Alps, on the east side of the Norwegian mountains, and among the mountains of England and Scotland; and those which are formed in level countries from the want of a sufficient declivity to carry off the water, such as the lakes in Finland, Poland, and Brandenburg. Four fifths of the lakes of Europe are in the country round the Baltic.

The soil of Europe has neither the extremes of luxuriance nor sterility which belong to the soil of the other great continents. If it does not yield the rich fruits of tropical climates, it is not deformed by the burning sands of Africa, or the pestilent swamps of America. It does not pour forth its riches spontaneously, but, soliciting the care and the labour of man, it requites his industry with what is necessary to supply his wants; and, by exercising and sharpening his powers of mind, has given birth to those arts which place the productions of the most favoured climates at his disposal. Many of the plants which have been domesticated in Europe are natives of distant countries. The vine, the olive, and the mulberry, are said to have been brought from Syria by the Greeks; the Arabians introduced cotton; maize was received from the Indian tribes of America; the walnut and peach come from Persia; the apricot from Armenia; and the sugar-cane from China. There are not very many plants belonging to the tropical regions that absolutely refuse to grow in Europe, but an enlightened economy finds other productions more profitable. Besides sugar and cotton, the banana, the orange, citron, fig, pomegranate, and date, grow in the south of Europe. But the more delicate fruits are confined to southern latitudes, and disappear one by one as we advance northward. And it is worthy of remark, that the zones in which they grow generally follow the lines of equal summer heat, and run obliquely across the continent in the direction of south-west and north-east. If a line be drawn on the map from Brest to Konigsberg, skirting the southern shores of the English Channel and the Baltic, the zones that limit the growth of different plants will run nearly parallel with this line. (Young's *Travels in France*, i. 306.) This holds generally in the south and middle of Europe; but in the extreme northern parts, and especially with regard to plants that require a moderate heat continued for a considerable time, the lines that limit the growth of certain vegetables seem to follow a different course, and decline towards the south as we advance eastward, in consequence of the increasing severity and length of the winter. It is scarcely necessary to say, that the zones, traced as proper for different plants, only mark the limits within which their cultivation is found advantageous. Most of them will grow beyond these limits; but they either require some peculiar advantages of soil or situation, or they are less profitable than other kinds of produce.

The sugar cane, one of the most desirable tropical plants, grows in Sicily and the south of Spain, in the latitude of 37° and 38°. The culture of it, which was once extensive in the latter country, has not yet been entirely abandoned, even since sugar was procured from the West Indies. Cotton is cultivated in the south of Spain on a small scale, to a greater extent in Sicily, the south-east angle of Italy, and in Greece and its isles, as high as the latitude of 41½°; we find it again at Astracan, in the latitude of 46°. The

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[1] Laborde's *View of Spain*, ii. 122-125; Storch, *Tableau de la Russie*, ii. 250; Humboldt, *De Distrib. Geog. Plant.*

orange and lemon come to perfection in the west of Europe, only in the countries to the south of the Pyrenees and Apennines, within the latitude of 43° in Spain, and 44° in Italy. The olive does not succeed on the west coast of France in the latitude of 43°, but grows as far north as 44° or 45° on the east of France, and in Italy. Attempts to raise it at Astracan, in latitude 46°, have not succeeded, on account of the rigour of the winter. The fig and the pomegranate, which accompany the olive in the west of Europe, are found in the Taurida in the east, at the latitude of 46°, where the olive will not grow, a proof that these trees bear the winter cold better. (Young's *Trav.* i. 311; Storch, ii. 309.) The climate proper for maize is found to terminate on the west coast of France at 45½°; on the Rhine at 49°; on the Elbe at 50° or 51°. Rice has nearly the same geographical range, but requires a peculiar soil and situation.[1] The culture of the vine extends as far north as the latitude of 47½° on the Atlantic coast; on the Rhine to 50½°; and on the Oder to 52°. In Russia it grows as far north nearly as 52°, but is not cultivated beyond 50°. (Young, i. 306; Storch, ii. 310, 323.) The mulberry generally accompanies the vine. The limits of the culture of the common cerealia are not so well defined, as the necessities of man oblige him to raise corn under the most unfavourable circumstances. In a general point of view, however, the parallel of 57° or 58° may be regarded as the northern limit of the cultivation of wheat in Europe. It is raised as far north as 60° or 61° in Finland, but only in some favoured spots. In Russia, generally, it is chiefly confined to the provinces under the latitude of 57°. (Thomson's *Trav. in Sweden*, 409; Storch, ii. 229, 240.) The hardier cerealia, rye, oats, and barley, are cultivated in some sheltered situations on the coast of Norway, as high as the latitude of 69° 55′. But on the east side of the Norwegian mountains these grains scarcely ripen in the latitude of 67° or 68°; and farther east, in Russia, it has been found impossible to carry cultivation of any kind beyond the latitude of 60° or 62°. Barley, which accommodates itself better than any other grain to these high latitudes, by shortening the period of its growth, is sown and reaped within the space of seven or eight weeks. But the introduction of potatoes promises to be of vast advantage in these cold regions, as this plant thrives and yields a produce of thirty or fifty fold in places where grain often will not ripen.[2] Peaches and apricots succeed with much care as far north only as the latitude of 50° in Russia; melons as far as 52°. The plum and the cherry grow wild as far north as 55°, but are carried farther by cultivation. (Storch, ii. 302, 304, 308.) Fruit trees and the oak terminate in Sweden, at Geffle, in the latitude of 61°; but the pine and the birch advance within the arctic circle; and the former grows to the height of sixty feet in the latitude of 70°. The black-berry and the whortle-berry grow in Lapland, and the gooseberry even in Greenland. Tobacco is extensively cultivated over the greater part of the continent of Europe, from Sicily to Sweden. Flax and hemp have as extensive a range as corn, but they are raised in the greatest perfection between the latitudes of 45° and 60°.

We have stated that the superficial extent of Europe is about 3,700,000 square miles. If we draw an incurvated line from a point in the Uralian Mountains, about the latitude of 60° or 61°, to the west coast of Norway, in the latitude of 69°, passing through the Lake Onega, and a little to the northward of the Gulf of Bothnia, this line will mark the extreme limits of cultivation, and will cut off a space equal to 550,000 square miles, or nearly one seventh of Europe. The space cut off, however, is not entirely useless, as a part of it produces pasturage and wood. The cultivation of rye, oats, and barley, is confined to the region south of this line, and includes more than five sixths of Europe; but in the northern parts of this zone only a very small proportion of the land will bear corn. The region adapted to the cultivation of wheat comprehends about four sevenths of Europe, and includes all the densely peopled parts. The region of the vine extends over three sevenths of Europe.

Metals.

Europe, in proportion to its extent, is probably richer in mineral wealth than the other quarters of the globe. It contains all the metals except platina; and though it affords gold and silver only in limited quantities, iron, copper, lead, with coal and salt, commodities of greater value to society, are abundant and widely distributed. The mountains, consisting of primitive and transition rocks, are the great depositaries of these mineral treasures.

Iron.

Iron is found in all the chains of mountains in Europe. The richest mines are in the Dofrines, or Scandinavian Alps. But rich mines are also found in the Alps of Stiria, Carinthia, and Bavaria; in the Pyrenees, the Vosges, the Cevennes, the coal district of Britain, the Urals, the Carpathians, the Hartz, and many other places.

Copper.

Copper is also widely distributed, though less abundant than iron. The richest mines are in Hungary, in the Carpathian Mountains. It abounds also in the Saxon and Bohemian mountains, in the Dofrines, the Urals, the north of England, and the Alps; and it is found in the Vosges, the Pyrenees, and other mountains of Spain, in the north of Germany, and in Tuscany.

Lead.

Lead exists in the Alps, Carpathians, Pyrenees, Cevennes, Vosges, the British mountains, and the Uralian chain.

Tin.

Tin is found only in a few places in Europe. The richest mines are in Cornwall; next to these are the mines in the Erzgebirge. It is also found in Hungary and Spanish Gallicia.

Mercury.

Mercury, like tin, is confined to a few places. The mines of Idria, in Austria, which yield 8000 to 10,000 quintals per annum, are the most productive in Europe. There are also considerable mines at Deux Ponts, in the Palatinate; in the Spanish province of La Mancha; and in Transylvania.

Gold.

Gold is widely diffused through Europe, but generally in such quantities as not to repay the expense of working. It is wrought, however, in the Carpathians, the Urals, the Dofrines, and the Alps. Anciently there were rich mines of gold in Spain and Greece.

Silver.

Silver is more abundant than gold, though less widely distributed. There are productive mines of this metal in the Erzgebirge, the Carpathians, the Urals, the Norwegian Dofrines, and in Sardinia. It is found also in the Alps, the Vosges, and the Sierra Morena.

Coal.

Of coal, the richest mines are found in the north and west of England. It abounds also on both sides of the south of Scotland; in Ireland; in the Netherlands; in one fourth part of the French territory; and occurs more sparingly in Saxony, Hanover, Denmark, Sweden, Russia, Hungary, Bohemia, Moravia, Silesia, Bavaria, Austria, Franconia, Westphalia, Swabia, Catalonia, and some other parts of Spain, in Portugal, and in Sardinia. After Britain, France is the country in Europe best supplied with this mineral. The produce of the French coal mines has increased fourfold within the last forty years.

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[1] Young, i. 306; Malte Brun, *Précis*, ii. 508; *Manuscript Travels in Germany.*

[2] Storch, ii. 209, 244, 304, 370; Von Buch. *Ed. Rev.* xxii. 163, 171; Crome, *Allgemeine Ubersicht, der Staatscraft von den Samtlichen Europaischen Reichen und Landern*, 1818, p. 108; Malte Brun, *Précis de la Géographie Universelle*, 1812, ii. 508.

Salt.

Salt is procured from the waters of the ocean, and, in the interior of Europe, from numerous salt mines and salt springs. The most productive salt mines in Europe are those in Poland, on the north side of the Carpathians, and those in Salzburg, on the north side of the Alps, both of which belong to Austria. There are also extensive depositaries of mineral salt in Transylvania and Hungary; in Valentia, Navarre, and Catalonia, in Spain; in Cheshire in England; and in Bavaria and Switzerland. Salt springs are numerous along the sides of primitive mountains in most countries of Europe. The most extensive salt mines of Russia are in Asia.

Antimony, cobalt, zinc, manganese, sulphur, alum, and a great variety of other mineral productions, are found in Europe; but it is unnecessary to specify their localities.

It is observed that the Alps, Pyrenees, Carpathians, and other mountain chains which run east and west, are richest in metals on the south side; while the Dofrines, Urals, and others which run north and south, are richest on the east side. Of the mountain chains of Europe, the Appennines are the poorest in metals, the Carpathians probably the richest.

Different races of inhabitants.

The present population of Europe is sprung from a variety of tribes; but authors differ much as to the number and peculiar characters of the original races. It would serve little purpose to enumerate the contradictory hypotheses which have been advanced on this subject. We shall therefore confine ourselves to an account of those more obvious general characters, founded on language, manners, or physical constitution, which distinguish the different portions of the population of Europe at present.

The nations in the south-west of Europe, the French, Italians, and Spaniards, speak languages in which the Latin idiom predominates. They have generally black hair and black eyes, and are rather inferior in stature to the Gothic nations, but gifted with more imagination and a higher degree of organic sensibility; they are more temperate, more inventive, but less persevering.

The Gothic race includes the English, Swedes, Norwegians, Danes, Netherlanders, and the various German nations inhabiting the country between the Rhine and the Oder, with the Swiss, Bavarians, and a part of the inhabitants of Bohemia, Moravia, and Austria. These nations are distinguished by fair hair, blue or grey eyes, large stature, and a clear complexion. They have less imagination than the southern nations, are more addicted to pursuits that exercise the understanding, are more thoughtful and serious, and less temperate in drinking.

The Sclavonic nations occupy the east of Europe generally, including Russia, Moldavia, Poland, ancient Prussia, with the greater part of Silesia, Hungary, Moravia, Bohemia, Croatia, and Sclavonia. They are rather lower in stature than the Gothic race, the countenance is shorter but more animated, and the hair black. The prevailing religion is the Greek Christian, and in the western parts the Roman Catholic. They all speak dialects of the Sclavonic language, of which the Russian is one.

The remains of the Celtic tribes are found in the Highlands of Scotland, in Wales, Ireland, Bretagne, and Biscay in Spain. They are rather low in stature, have lively eyes, prominent cheek-bones, red or yellow hair in the north, but sometimes black hair in the south.

The Finns, with the Esthonians, Karelians, and other tribes in the north of Europe, have a language of their own, and the characters of a peculiar race. They have light brown eyes, a pale complexion, cheeks hollow, are of middling stature, but heavy and muscular.

The Samoieds, Laplanders, and other tribes who live within the polar circle, are distinguished by their very low stature, the smallness of the legs and feet, and largeness of the head, prominent cheek-bones, small round black eyes, black and bristly hair, and a swarthy skin. The Laplanders, from intermixture with the Finns, Russians, and Norwegians, have lost in some degree the characteristic traits of the original race.

The modern Greeks and Albanians are supposed to be descended chiefly from the ancient inhabitants of the country, whose language they have preserved. They have a greater resemblance to the Latin nations than to those of the Gothic race. The Turks are an Asiatic tribe.[1]

Prog s
of ci za-
tion

Europe has been gradually advancing from poverty and barbarism to wealth and refinement since the tenth century; but the progress of the different nations has been very unequal. No single cause has contributed so much to their improvement as commerce; and hence the first advances have always been made by maritime states; and the progress of the different communities has been nearly in proportion to their vicinity to the sea, or the facility of their communication with it. The small republics of Italy and the Hanse Towns were the seats of industry, wealth, knowledge, and freedom; while slavery, ignorance, and rapine, reigned in the countries around them. The tendency of commerce to enrich a country seems to depend on its power to create disposable capital. Though a certain species of opulence exists among the great landholders of agricultural countries, those masses of disposable capital which give vigour to industry, and supply the means of great improvements, are only found in commercial states. Commerce also favours the growth of manufactures, and these two species of industry raise up a middle class, closely allied with the great body of the people. It is among this class that ideas of civil and religious liberty take their rise, and find their firmest supporters; whereas in countries entirely agricultural, liberty means only the domination of the aristocracy. The spirit of liberty once introduced, laws are improved, prejudices hostile to industry extinguished, and new vigour infused into every branch of society. It is thus that freedom and wealth have generally followed in the train of commerce; and that the commercial states have led the way in those improvements which have so much ameliorated the condition of Europe. When the Italian republics flourished, however, Europe was not in a state to be much benefited by the lights their experience afforded. The Dutch republic, which flourished at a later period, gave a more striking demonstration of the advantages of industry, freedom, toleration, and good government, at a time when neither liberty nor toleration were understood even in England, and when industry was in a very low state all over Europe. The example of the Dutch furnished statesmen with new ideas, and had a sensible influence on the policy of England, France, and other countries. The genius of Peter the Great derived from this small republic the seeds of those improvements by which civilization was spread over the vast empire of Russia. The superiority which the Dutch possessed has since been transferred to Britain, and she has acquired with it the privilege of instructing other nations in the sources of public wealth and the science of government.

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[1] Adrien Balbi thus classifies the population of Europe into families: 1. The Iberian or Basque family, in Northern Spain and Southern France; 2. The Celtic family, embracing the Scotch Highlanders, the Welsh, and the Bas-Bretons; 3. The Thraco-Pelasgique, or Greco-Latin family, embracing the Albanians, Greeks, Italians, Wallachians, part of the inhabitants of France and Spain; 4. The Germanic family, comprehending the Germans, Netherlanders, Danes, Swedes, English and Lowland Scots; 5. The Sclavonic family, comprehending the Russians, Poles, Wends, Bohemians, Illyrians, Lithuanians; 6. The Uralian family, including the Finns, Tchoudes, Laplanders, and Magyars of Hungary; 7. The Samoieds. (*Abrégé de la Géographie*, p. 103. Paris, 1833.

The Reformation had a material effect in accelerating the progress of society. It put an end to a multitude of abuses and prejudices adverse to improvement, and inspired the human mind with a new activity. Those countries in which it took no root seemed to have had their progress arrested; while others, less favoured by nature, derived new life and vigour from its influence. Italy and Spain, now so far behind Britain, France, and Germany, were the first countries in Europe for knowledge, wealth, and industry, at the period of the Reformation. The establishment of the Protestant religion has produced a more liberal spirit among the Catholics in those countries where the two churches exist together; but in those countries where Protestantism has never obtained a footing, the dread of its introduction has thrown the government more and more into the hands of the clergy; the clergy, armed with power, have become more jealous and intolerant, and have nearly put an end to all freedom of thought. The literary glory of Spain expired some time after the Reformation; and Italy has been checked in her career. The older writers of these countries breathe a spirit which would not be tolerated at the present day, nor does society there afford the elements out of which such characters could be formed. And thus it happened that the very same event which called forth the powers of the human mind in the north of Europe, extinguished the intellectual activity of the south.

The improved means of internal communication in countries in modern times have had a considerable effect upon the state of society. In ancient times free states were necessarily small, because when neither the press nor the post existed, that union of sentiment necessary to control the conduct of men in power could not be effected among a large population scattered over a wide space. A number of free states sprung up in Greece, because that country, perforated by mountains and arms of the sea, afforded natural means of defence to such small societies as could then exercise the functions necessary to the preservation of freedom. It is a mistake to suppose that, in these states, a greater extent of territory could have been united under one government by adopting the representative system. The resolutions of a body of representatives would command no more respect from a government than those of as many private individuals, if they were not constantly supported by the opinions of the mass of society; and this requires such a rapid and general circulation of intelligence as could not then exist. The small size of the Grecian states was a necessary condition of their freedom; but it was a serious disadvantage, not only because it lessened the commercial intercourse between the different parts of the country, but because such small communities had not strength enough to resist a great force from without; and hence these states fell a prey to the superior power of the Macedonian monarchy. The whole of the south-west of Europe exhibits the physical features of Greece upon a larger scale. Its surface is broken into numerous sections by gulfs and mountains, and abounds in natural barriers. Favoured by these circumstances, the different communities in this quarter of the world in modern times enjoyed a certain degree of independence and security, which hastened their progress in civilization. Russia, which occupies the only large plain in Europe, has been the last reclaimed from barbarism. So long, however, as the means of communication remained very imperfect in modern Europe, free governments were confined to small states, and the larger states were abandoned to feudal tyranny or military despotism; but the science of government has gradually improved, as knowledge, commerce, and the arts have advanced; and at present the admirable inventions of the post and the press give such an electric rapidity to the circulation of public sentiment, that twenty millions of men could be as easily united in defence of their rights as the small population of Attica in the time of Xerxes.

The progress of improvement tends to level all distinctions between states, but those founded on the extent of their natural resources. Capital, skill, intelligence, and all acquired advantages, tend to an equilibrium. When Europe was overrun with barbarism, the city of Venice, by its commercial wealth, was a counterpoise to two or three of the great monarchies of the continent. The discovery of America, and of a passage by sea to the East Indies, gave a new direction to commerce, and undermined the greatness of that city. The Dutch republic rose by its freedom and industry, and was able, in the time of Charles II. to dispute the empire of the sea with the combined powers of England and France. But England increased her commerce, and improved her constitution; and having a larger and more fertile territory, as well as a greater population, she at length obtained an ascendancy over Holland, deprived her of the empire of the sea, and stript her of most of her colonies. At the beginning of the seventeenth century, Spain and Turkey were the first powers in the west and east of Europe, and inspired their neighbours with the dread of conquest. Sweden ruled with undisputed sway in the north; and Russia, now so formidable, was scarcely known. Spain, under a better government, might recover a part of her influence; but the Turkish empire seems near its dissolution; and the importance of Sweden and Holland is gone irretrievably, in consequence of the growing strength of the neighbouring powers. The extent of territory and immense natural resources of Russia must, in the end, raise her to a decided superiority over all the other powers of Europe, if the empire does not fall to pieces from its own weight, or get into disorder from the vices of its government. Its progress hitherto has been greatly aided by the personal characters of its sovereigns. If we were to judge merely from the advantages which different states possess for raising and supporting population, we might predict that, in the course of a century and a half, Russia would rule with uncontrolled sway over the old continent, and the United States over the new; and that the other states, which now figure in the first rank in either hemisphere, would then owe their existence, like the small principalities of Europe at the present day, to the forbearance or the mutual jealousy of their powerful neighbours. But in the course of events, many changes may occur to give a different destiny to both continents.

Number of inhabitants.

The number of the inhabitants of Europe has been progressively increasing, slowly in the earlier part of the century, but more rapidly as we approach the present times. Apparently it has been least considerable in Spain, Italy, Sweden, France, and Germany; greater in Russia, Austria, and the British isles; and greatest in Prussia. In 1787, Zimmermann estimated the population of Europe at 144,000,000; and in 1833, according to Balbi, it was 227,000,000. The increase of 83,000,000 in forty-six years implies an annual augmentation of 994 upon 100,000, or very nearly one per cent.; and if this ratio were constant, the population of Europe would double itself in seventy years and a half. In 1827 Baron Dupin estimated the increase in the principal states of Europe to be as follows.[1]

	Annual Increase on one Million.	Period of doubling.
Prussia	27,027	26
Britain	16,667	42
Netherlands	12,372	56½
Two Sicilies	11,111	63
Russia	10,527	66
Austria	10,114	69
France	6,536	105

A comparison of the census for 1821 and 1831, the only two which include Ireland, shows that Dupin's estimate for Britain is too high. The annual increment for the three kingdoms scarcely exceeds one seventy-fifth part, or 13,400 upon a million. The increase in Prussia has been so very rapid, we presume, only since the peace in 1815. The most obvious cause of this increase of population is the increase of production, from the improvement of agriculture and the arts; but part of the effect may be ascribed to the general introduction of potatoes in many countries, by which the same portion of ground is made to support three or four times as many persons as it would under corn. In France, where Mr Young, in 1789, found the cultivation of potatoes extremely limited, it was so much extended in 1819, that, according to Chaptal, the annual produce was nearly 20,000,000 hectolitres, or 55,000,000 bushels; a quantity fully as great in proportion to the population as Mr Colquhoun assigns to Britain and Ireland. This augmentation of numbers does not appear to have been accompanied with any deterioration in the habits of the people. On the contrary, the diminution in the rate of mortality which has taken place in Britain, France, and Sweden, is a decisive proof of an improvement in the condition of these countries; and, by analogy, we may extend the same conclusion to the other parts of Europe. It may be remarked, that the general extension of commerce, and the accumulation of capital, render a season of scarcity, in a particular country, much less destructive now than formerly. In Britain, whose commerce and capital enable her to draw supplies from all parts of the world, the additional mortality, in the most severe scarcity, does not exceed one tenth; but in Sweden, a poor country, it sometimes amounts to one third. (Milne's *Annuities*, p. 400.) In ancient times, when each country depended entirely on its own produce, the effects of a scarcity were dreadful.

Number of states, and their comparative importance.

The states of Europe at present are 62 in number, and, considered with respect to political importance, may be divided into four classes. Britain, France, Russia, Austria, and Prussia, belong to the first; Spain, Sweden, Turkey, to the second; Holland, Belgium, Portugal, Naples, Bavaria, Sardinia, Denmark, Saxony, Wirtemberg, Hanover, and Switzerland, to the third; Baden, Tuscany, and the States of the Church, with the other small states of Germany and Italy, belong to the fourth class. Objections may be made to this classification, but we have not been able to find a better; and a few remarks will explain the principle on which it is founded. The first five powers are the only powers that exercise a decided influence over their neighbours; and it is by their joint counsels that differences among the smaller powers are adjusted, and all questions that concern the general state of Europe decided. The three states of the second class visibly occupy a lower place in the scale of power than those of the first. They have very little exterior influence, but they are not directly controlled by any of the stronger powers; and it is only among them and the states of the first class that wars are now likely to originate. The third class includes those states which are too feeble, and too much under the influence of the great powers, to become principals in war, but are of importance enough to be valued as auxiliaries by states of the first and second classes. The fourth class consists of states which have too little force to maintain any degree of independence, and owe their existence to the justice, the forbearance, or the mutual jealousies of the stronger powers. It is only in Europe that small states exist among large ones; and their existence is the consequence of that equality of power among the great states, which compels each to respect the rights of the others, and to pay a certain degree of deference to public opinion.

A detailed account of the principal European states is given under the proper heads, in their alphabetical order. Our object here is only to bring together such general facts as will afford a comparative view of the internal condition, power, and resources of those larger societies which comprise the greatest part of the population of Europe. With respect to the smaller states, we cannot make room for any further details than what are contained in the table which forms the conclusion of this article.

BRITAIN.

Though much smaller in extent than any of the other states of the first rank, Britain is the most wealthy and powerful of the whole. She has a moderately good climate, a soil less fertile in grain than that of France, but affording better pasturage; an extensive line of sea-coast, with numerous harbours; a natural and well-defined frontier, a good commercial position, and the largest fields of coal in Europe. But all these advantages have contributed less to her aggrandisement than the excellence of her laws and constitution. The progress of Britain in commerce, manufactures, and agriculture, within the last century, and especially within the last forty years, has been wonderfully great.

The British isles contain about 76,000,000 of acres, of which about 49,000,000 are in cultivation, and 27,000,000, or more than one third, waste or uncultivated. About one half of the waste land is in Scotland, where the cultivated soil forms only twenty-six parts in the 100 of the whole surface of the country; in England it forms eighty-two parts in the 100, and in Ireland sixty-nine.[2] The agriculture of Britain, compared with that of the continent, is distinguished by the farms being generally larger, the plan of cultivation more systematic and skilful, the produce on equal soils greater, the pasture land bearing a higher proportion to the land in tillage, and the breed of animals being superior. In Scotland the pasture land forms about one half of the land in cultivation; in England, four sevenths. The whole annual produce of grain in Britain and Ireland was estimated by Dr Colquhoun in 1812 at 35,000,000 of quarters, excluding seed; of which wheat is supposed to form twenty-six parts in the 100 in quantity, barley seventeen parts, oats forty-nine, rye two, peas and beans five. The value of the annual produce of grain was computed by the same author at L.73,700,000;

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[1] Dupin, *Forces Productives et Commerciales de la France*, 1827, tom. i. p. 35.

[2] Colquhoun's *Treatise on the Wealth, Power, and Resources of the British Empire*, 1815, p. 56, 57; Sir J. Sinclair, *General Report of the Agricultural State of Scotland*, vol. iii. addenda.

that of the pasture land at L.89,200,000; and the whole gross produce of all the branches of agriculture, including gardens and cattle, at L.216,000,000. But as this estimate was made in 1812, when prices were uncommonly high, a third or a fourth should be deducted for the present value. The valued rack-rent of England and Wales, as returned to parliament by the commissioners of taxes in 1810, was L.29,503,073, which gives 15s. 6d. as the average of rent of all kinds of land per acre. The rental of Scotland in 1813, according to Sir John Sinclair, was L.5,041,779, including mines and fisheries; and deducting L.341,000 for these, the rent of land would be L.4,700,000, or 4s. 11d. per acre on an average.

The progress of Britain in manufactures has been still more rapid, within a recent period, than in agriculture; and her natural advantages for this species of industry are perhaps more exclusive. She has a good supply within herself of the raw material for all her staple manufactures except cotton; and her means of procuring this article are at least equal to those of her neighbours. The growth of this manufacture in Britain has been unprecedentedly rapid. In 1767, the value of all the cotton goods manufactured did not exceed L.200,000, and in 1832 it was estimated at L.36,000,000. The produce of the woollen manufactures, in the same year, including the raw material, was estimated at L.22,000,000; that of leather at L.10,000,000; of linen at L.12,500,000. (M'Culloch's *Commercial Dictionary*, 1832.)

The commerce of Britain seems to have increased pretty regularly during the first sixty years of the last century; but from 1760 to 1786 it remained almost stationary. From this period to the present time the increase has been rapid beyond example. The exports of England, about 1700, were L.6,045,000; in 1760, L.14,694,000; in 1786, L.15,385,000. (Chalmers' *Hist. View.* p. 315.) In 1832, the official value of the exports was L.76,071,000, of the imports L.44,586,000. The mercantile tonnage in 1832 was 2,618,000 tons, and the number of seamen 161,600. (*Parliamentary Papers.*) The annual produce of foreign commerce, or the sums derived from it by all classes concerned in it, were estimated, in 1812, at L.46,373,478; the gains from inland trade at L.31,500,000; and the whole annual produce of industry, from all sources, at L. 430,000,000 (Colquhoun, p. 96–100); an estimate which is certainly exaggerated.

The growing wealth of Britain has had to sustain an increasing weight of public burdens. The public revenue of England, at the Union in 1709, was L.5,691,803; of Scotland, L.160,000. In 1763 (a year of peace) the net revenue was L.9,100,000; in 1790 L.15,986,068; and in 1812 it was L.64,979,960, of which England furnished L.55,995,123, Scotland L.4,155,599, and Ireland L.4,882,264. (Colquhoun, p. 262.) In the year 1832, the net produce of the revenue was L.51,474,000, which was collected at an expense of L.6. 13s. 11d. per cent. The nominal amount of the public debt at 5th January 1833 was L.754,000,000, the interest L.27,703,000. The unfunded debt was L.35,373,000. The army in 1832 consisted of 95,800 men, exclusive of 17,200 in India. The number of men voted for the navy was 27,000. (*Parliamentary Papers.*)

The population of England appears to have doubled in the hundred years ending 1811; that of Scotland appears to have increased one half in the same period; that of Ireland has also increased very rapidly. In the period between 1801 and 1831, the rate of increase in England and Scotland was such as would have doubled the population in forty-six years. This rapid increase of numbers appears not to have been accompanied with any deterioration of condition. In the five years ending 1784, the annual mortality in England and Wales was one in thirty-seven; in the five years ending 1810, it was one in 47·86. Of the population of Britain and Ireland, about thirty-five families in the hundred are employed in agriculture, forty-five in trades, manufactures, and handicrafts, and twenty in other occupations. The total population of Britain and Ireland in 1831 was 24,304,000. To these must be added about 98,000,000 in the colonies, making a total of 122,000,000.

FRANCE.

This country enjoys, upon the whole, greater natural advantages than any other in Europe. Her territory is above one half larger than Great Britain and Ireland, and is superior in soil and climate. She has a greater proportion of arable land than any of her neighbours; the natural means of communication between her provinces are abundant and easy; she is well provided with all the useful metals except tin; and is better supplied with coal than any other country in Europe except Britain. When we add to these advantages the intelligence and activity of her population, and consider that corvees, tithes, feudal services, and most of those abuses which shackled her industry, are now removed; that she is likely to enjoy the benefits of good laws and a free constitution, and is not encumbered with a great national debt; we cannot doubt that, if peace continue for any considerable length of time, she will yet rise to a much higher degree of wealth and prosperity than she ever before possessed. Even during the distractions of the Revolution, though her commerce was annihilated, her agriculture and manufactures extended and improved, her population increased, and its condition was ameliorated. The greatest bar to her progress will probably be the extreme division of property; and, for some time also, the want of capital.

The surface of France contains within its present limits 52,000,000 hectares, or 128,000,000 acres. From partial surveys, for fiscal purposes, made in each department, it is estimated that the waste land, including roads and rivers, amounts to one eighth of this, or twelve parts in the hundred; the arable land to forty-four parts in the hundred; the woodland to fourteen parts; the pasturage land and meadows to fourteen; the vineyards to four; wild land seven; quarries, buildings, orchards, gardens, olive and other plantations, make up the remaining five parts. (Chaptal, *De l'Industrie Française*, i. 205. Paris, 1819.) In addition to the vegetable productions that grow in England, the climate of France enables her to raise maize, vines, olives, mulberries, and chestnuts; and by some of these a produce is extracted from soil which in England would yield nothing. The whole produce of grain in France is estimated by Chaptal at 143,000,000 hectolitres, equal to 50,000,000 quarters, or 40,000,000 deducting one fifth for seed, which is only 5,000,000 above the produce of Britain and Ireland, as estimated by Colquhoun. Of this produce of grain, wheat forms thirty-six parts in the hundred, rye twenty-one parts, maize four and a half, buckwheat six, barley nine, oats twenty-two, legumes one. The quantity of potatoes (19,800,741 hectolitres) is equal to two thirds of the rye. The produce of 4,000,000 of acres planted with vines, in 1808, was 37,600,000 hectolitres of wine. (i. 173,177.) The *annual gross produce* of the land, which was estimated by Arthur Young at L.230,000,000 sterling, is estimated by Chaptal at 4,678,000,000 francs, or L.187,000,000 sterling,[1] of which the principal items are,

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[1] Reckoning the pound sterling equal to 25 francs. See the article EXCHANGE.

Corn and legumes (secs),	L.77,172,000
Vines	28,757,000
Forage	27,322,000
Wool	3,253,000
Raw silk	617,000
Hemp	1,237,000
Flax	760,000
Woods and forests	5,657,000
Cattle, sheep, and swine	17,880,000
Poultry	2,588,000
Fruits	2,584,000
Pulse and other esculent vegetables (legumes frais)	7,872,000

(Chaptal, i. 226–238; Young, i. 468).

Revenue imposable.

The mean revenue derived from a hectare of land is estimated by Dupin at thirty and a half francs, or 25s. 5d. equal to about 10s. 3d. per acre; and the revenue of the whole departments, calculated on this basis, is L.65,000,000. The last sum includes houses, and may be considered as corresponding nearly to the rack-rent of lands and buildings in France. This is certainly too low. The average rent of all kinds of land in France was estimated by Young at 15s. 10d. per acre. (*Trav.* i. 476.) The most peculiar feature in French agriculture is the vast number of small proprietors, who cultivate their patches of land by their own labour. Arthur Young supposed that, before the Revolution, one third of the property of the kingdom was held by such persons; and Chaptal says the number of proprietors is doubled within the last thirty years. The latter computes the whole number of farms in France at 3,000,000; so that, on an average, each cannot exceed forty-three acres, including wastes. In the cultivation of good soils, the agriculture of France is nearly equal to that of England; but it is greatly inferior in the management of poor soils, in the system of cropping, and in the breed of animals. It has been much improved, however, during the Revolution, by the extensive cultivation of artificial grasses, by augmenting the live stock, by the general exclusion of fallows, and by increasing the cultivation of potatoes.[1]

The manufactures of France, amidst all the troubles of the Revolution, have been generally advancing, though some branches have retrograded. The number of workmen employed in Lyons, the principal seat of the silk manufacture, was one fourth greater in 1812 than in 1789. France produces within herself about eleven millions of pounds of raw silk, and imports nearly as much; and the total value of the manufactured articles produced is estimated at L.4,300,000. Of wool, France produces about ninety-three millions of pounds, valued at L.3,253,000, and imports seventeen millions of pounds, which, converted into various fabrics, is estimated to be worth L.9,500,000 sterling. The value of the manufactures of flax and hemp is estimated at L.9,612,000. The spinning of cotton by machinery, which was scarcely introduced before the Revolution, employed one million of spindles in 1812; in that year there were 23,000,000 pounds of cotton spun; in 1825 there were 62,000,000. The value of the cotton goods manufactured is estimated at L.7,600,000. The manufactures of iron in France are estimated at L.8,300,000; those of leather at L.5,700,000. The whole gross produce of manufacturing industry, including manufacturers' profits, is estimated at 1,802,000,000 of francs, or L.72,800,000, of which the value of the raw material forms thirty-two parts in the hundred, wages forty-seven, manufacturers' profits ten, and expenses eleven. (Chaptal, ii. 116, 203; Dupin, tom. i.)

The exports of France in the year 1827 amounted in value to 602,000,000 francs (L.24,000,000); the imports to 565,000,000 (L.22,600,000). The leading articles of exportation were silk goods, raw silk, cottons, linens, wines, and woollens; the leading imports were raw silk, cotton, linen, and coffee.

The population of France, notwithstanding the interruption to industry, and the drains occasioned by the long wars, has increased since the commencement of the Revolution. According to calculations made by the National Assembly in 1791, France contained 26,363,074 inhabitants, and in 1831 it contained 32,560,000 within the same limits. (*Annuaire pour l'An* 1834). The annual increase is about 200,000 individuals. The condition of the labouring classes appears to be improved. Wages, which Arthur Young estimated at 19 sous, or 10d. English per day, throughout the kingdom, for all kinds of work, were estimated at 1s. 2d. by Dupin, in 1827. The annual mortality, which was estimated at one in thirty by Neckar before the Revolution, we find stated recently to be one in forty. (*Annuaire pour* 1834.)

According to returns made in 1815, there were then in France 22,300 primary schools, with 737,379 pupils. There were, besides, 368 secondary schools, thirty-six lycees, and twenty-six universities. In 1833 there were 44,500 primary schools, which were attended by 1,907,000 pupils of both sexes.

The ordinary revenue of France, in the year 1831, was 973,000,000 francs, or L.39,000,000. The debt was 5,400,000,000, or L.216,000,000, and the annual interest 283,000,000, or L.11,300,000. There are about 40,000 parish priests in France, whose pay, with that of the bishops, amounts to L.1,200,000.

From the commencement of the Revolution to 1810, France received great accessions of territory. The peace of Luneville left her in possession, in whole or in part, of the Austrian and Dutch Netherlands, the bishoprics of Liege, Cologne, Trèves, Mentz, duchy of Juliers, the Palatinate, Mœurs, Guelders, the department of Mont Blanc, Leman, Maritime Alps, with the Venaissain, Montbeliard, and other *enclavés*. These various districts comprehended a surface of 27,400 square miles, and a population of 5,025,000.

Between 1801 and 1810 she acquired Piedmont, Genoa, Tuscany, Parma, the Roman States, the Valais, the Illyrian provinces, with Venetian Dalmatia; Holland, Bremen, Hamburg, Lubec, Munster, Osnaburg, and part of Hanover. These districts comprehended a surface of 110,000 square miles, and a population of 16,057,000. With these additions the French empire, in 1812, included an area of 310,000 square miles, and a population of 44,500,000.

If to these we add the states dependent upon France; namely, the Cisalpine Republic, 31,000 square miles, with 6,350,000 inhabitants; the Confederation of the Rhine, 113,000 square miles, with 14,000,000 inhabitants; and Naples, 30,500 square miles, with 4,960,000 inhabitants; we have an aggregate of 486,000 square miles, and a population of nearly 70,000,000. The kings, princes, or chiefs of these dependent states, were in reality nothing more than Napoleon's viceroys; and it may be said with truth, that in 1812 the resources of the vast population of seventy millions now enumerated were at his disposal.

By the peace of Paris in 1815, France was stript of all her conquests, and reduced within her ancient limits, as they stood in 1789, with some inconsiderable variations, not sensibly affecting her whole extent of territory, or amount of population.

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[1] Chaptal, i. 139, 144, 153, 224, &c. Birkbeck's *Tour in France*, 1814, p. 109.

AUSTRIA.

The Austrian empire is one fourth larger than France, and twice as large as Britain and Ireland. Its population consists of a mixed mass of nations, differing in origin, language, religion, and manners, having few common ties, and little intercourse with one another. Austria has but a small extent of sea-coast, and is almost entirely an inland power. The climate is similar to that of France, but subject to greater extremes of heat and cold, the soil not much inferior, the grain and fruits nearly the same. She is richer in mineral wealth than any other state in Europe, and possesses coal, though not in great abundance. Her natural resources are capable of vast improvement; and in the hands of a wise and liberal government, would soon raise her far above the rank she now enjoys. Of the six sections into which her territories are divided, Lombardy is the most populous in proportion to its extent; Bohemia and Moravia are next in population, and are the seats of the chief manufacturers; Austria Proper and Hungary are remarkably rich in mines; and Galicia, though in a low state of cultivation, is fertile in grain, and contains the most productive mines of salt in Europe. Austria has but a slender title to be regarded as a German power; less than one fifth of her population are Germans. The Sclavonic race, who form nearly one half of the population, give a character of ignorance and backwardness to the government. In Bohemia, Hungary, and other provinces where this race predominates, vassalage exists in some of its forms, and cramps the progress of society. The Austrian empire, in truth, consists properly of six separate governments, feebly united under one head. Each of these governments, except that of Lombardy, has a diet or states, composed of the deputies from the nobility, clergy, and towns; but these bodies exercise no real influence over the government, except in Hungary, where the old feudal institutions remain in vigour, and the aristocracy have always maintained a great degree of independence.

The surface of the Austrian monarchy is estimated at 258,000 square English miles. Of this surface, the waste lands, including morasses, mountains, rivers, and ground covered with buildings, are estimated at five parts in twenty-four, the useful soil at nineteen parts in twenty-four; and of the useful soil about forty-three parts in the hundred are in tillage, nine parts meadow land, nine parts commons, which support cattle, two parts vineyards, two parts gardens and orchards, and thirty-five parts forest land. The total produce of grain is estimated at 165,500,000 metzen, or about 35,670,000 quarters, consisting of wheat fourteen parts, barley eleven, rye thirty-one, and oats forty-four. In 1804 the net produce of a joch (equal to one acre and a half) of corn land, for the whole Austrian states, was valued by Lichtenstern at five florins (10s.), and of pasture land at two florins (4s.) (Hassel's *Stat. abris des Oest.* p. 90.) The annual produce of wine in the Austrian dominions is estimated at from 36,000,000 to 40,000,000 of eimers (each equal to fourteen English gallons), of which Hungary furnishes nearly two thirds. This is rather more than one half of the produce of the French vineyards. Galicia is the only province in which there are no vines. Hungary and Sclavonia supply 180,000 centners of excellent tobacco. The Ex-Venetian states furnish yearly 1,200,000 pounds of silk; Milan and the Tyrol nearly as much; and altogether this species of culture employs 400,000 persons. Flax, hemp, hops, and fruits, are also extensively cultivated; and the forests, which cover more than one fourth of the empire, furnish an ample supply of wood. The total produce of the vegetable kingdom is valued at 68,500,000 sterling, a small amount, considering the extent of the country; but agriculture, though there are numerous societies for its improvement, remains in a low state, from the prejudices of the higher classes, and the oppressions to which the peasantry are exposed. The horses in the empire are estimated at 1,800,000, the sheep at 12,000,000, and the horned cattle at 10,000,000. The live stock has greatly diminished within the last twenty-five years. The annual produce of the mines is 3846 marks of gold (the mark is about three fourths of a pound Troy); 486 centners (hundredweights) of silver, 56,000 centners of copper, 30,000 centners of lead, 4890 centners of tin, 1,200,000 centners of iron, and 5300 centners of mercury. About 5,500,000 centners of salt are prepared, the greatest part from salt mines and springs. The annual produce of these minerals in 1802, when it was probably one third less than the above, was valued at L.4,700,000.[1]

The leading manufactures are linen, cotton, woollen, silk, leather, and works in metal and wood. The linen manufacture existing in all the provinces, but to the greatest extent in Bohemia and Moravia, is supposed to employ 1,200,000 persons; the woollen manufacture 300,000 persons; the cotton 100,000: about 18,000 or 20,000 centners of cotton were spun by machinery in 1817, which is three times the quantity spun in 1803. The silk manufacture, which is carried on chiefly in Lombardy, employs 110,000 persons. The most considerable manufactures in metal are in Styria, Carinthia, and Lower Austria. The estimate of the annual products of the Austrian manufactures, given by Crome, is too extravagant to deserve any credit. But those of Bohemia, in 1811, were valued at 158,000,000 of florins; and if we add twice as much for all the other states, the whole produce of the Austrian manufactures may, on this ground, be computed at L.47,000,000 sterling. Even this is probably above the truth. (Lichtenstern, p. 44; Crome, 173–176.)

The commerce of Austria is extremely trifling. She possesses but a small extent of sea-coast, which is remote from the centre of her territories, is destitute of navigable rivers, and rendered difficult of access by mountains. The numerous rivers that water her dominions afford few advantages to her trade, as, excepting in Italy, she does not command the outlet of any one of them. The whole exports of this large empire are only L.3,000,000, and the imports L.3,200,000. (Lichtenstern, p. 48.)

The population of the Austrian empire, in 1817, was 28,207,886, of which the Sclavonic race amounted to 13,182,000, the Germans to 5,342,000, the Italians to 4,226,000, the Magyars or Hungarians to 4,225,000, the Wallachians to 1,246,000, and the Jews to 487,000. (Lichtenstern, p. 1858.) In 1832 Balbi estimated the population at 32,000,000. There are, besides, considerable numbers of Greeks, Turks, Albanians, and Armenians; so that, except Russia, no state in Europe has such a heterogeneous population. Throughout the Austrian dominions, the nobility and clergy are numerous, and many of them very rich. In Hungary, Galicia, and indeed in the greater part of the empire, these classes are exempt from taxes, and enjoy other pernicious privileges. The Austrian clergy, exclusive of their families, are estimated at 64,000, of whom 56,000 belong to the Catholic church; the nobles of both sexes at 475,000; the civil servants of the government, with their families, at 280,000; the military, men, women, children, and servants, at 800,000; the burghers and tradesmen, with their families, at 2,333,000; the persons engaged in agriculture at 4,005,000 families, or about 20,025,000 individuals. (Lichtenstern, p. 133.) In all the provinces, especially in Bohemia, Moravia, and Hungary, there has been a rapid increase in the numbers of the inhabitants. Though the people are poor and ignorant, the government has been at much pains to provide them with the means of instruction; and the numerous schools and academies established must essentially contribute to the improvement of the country. The Catholic religion, though it predominates, nowhere enjoys that exclusive ascendancy which produces such pernicious consequences in Spain and Italy. The other sects, Greeks, Calvinists, Lutherans, form nearly one third of the inhabitants in the provinces beyond the Alps; and this circumstance, by generating a certain freedom of thought and discussion, must prove favourable to the progress of society.

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[1] Lichtenstern, *Handbuch der Neust Geog. des Oest.* 1818, p. 33–42. Crome, *Allg. Ubersicht*, 1818, p. 141–154.

Prussia.

Prussia is the smallest in extent, and enjoys the fewest natural advantages, of all the European states of the first class. Her territory is not much more than two fifths of that of Austria; it is but indifferently fertile; has few valuable mines, few resources for manufactures; she has, however, pretty large extent of sea-coast, and a considerable commerce. Her possessions are straggling and disjointed; they present an extensive frontier, with little depth, and no natural barriers; and are inhabited by people who speak different languages, and have few common ties or interests. Prussia has sustained her rank chiefly in consequence of the superiority of her internal organization. Her government, unlike those of the other monarchies of Europe, being of very recent origin, is not encumbered by those ancient establishments which the change of circumstances has converted into abuses. The frame of her public institutions was much improved by the Great Frederick, who availed himself of all the lights and philosophy which the age furnished. He established a complete toleration in matters of religion; curtailed the oppressive privileges of the nobles; simplified the administration of justice; and introduced order and economy into every department of the government. He left the kingdom to his successor with a large and well-disciplined army, and a high reputation for policy and prowess. After the misfortunes in which Prussia was involved by the battle of Jena, the present king, aided by his enlightened minister Hardenberg, began a series of most extensive reforms, which have raised the oppressed peasantry to the rank of free farmers, or independent proprietors, reduced still farther the privileges of the nobles, released trade from the weight of incorporations, and created the most ample means of instruction for the whole population. The population of Prussia, of whom two thirds are Protestants, is more intelligent than that of Austria; includes a greater proportion of Germans; and altogether she is more of a German power. The large rivers that water her territories have generally a very level course; and being joined by canals, they afford a great extent of inland navigation. Of all the old provinces, Silesia is the most industrious and flourishing. It doubled its population in the seventy-three years between 1742 and 1815. The Westphalian and Rhenish provinces are the most populous; ancient Prussia and the Polish provinces the least. (Russell's *Travels in Germany*, 1824, vol. ii. p. 110.)

Agriculture has been greatly extended in Prussia, and somewhat improved in recent times. Besides the common species of grain, tobacco, mulberries, vines, flax, and hemp, are cultivated. Great quantities of potatoes are also raised. Horned cattle and sheep are pretty numerous in most of the provinces. M. Krug estimated the mean rent of an arpent of corn land, for the whole Prussian states, at $2\frac{1}{12}$ rix-dollars (about 7s.), and the *net produce* of an arpent of corn land at two fifths of the gross produce; but of pasture land at one fourth or one fifth only, including poultry and bees. According to returns made from the different provinces to the government, the whole annual produce of grain in Prussia about 1802, when the population was 8,754,000, was 4,500,000 wispel (equal to 9,600,000 quarters); of which wheat formed nine parts in the hundred, rye forty, barley twenty-four, and oats twenty-seven; of this quantity one tenth was exported. The Prussian silver mines yield annually about 20,000 mark of silver; the county of Manifield alone furnishes 14,588 centners of copper; and Silesia affords 7600 centners of lead, and 405,900 centners of iron. The principal manufactures of Prussia are linen, woollen, cotton, silk, leather, iron, and porcelain, all of which are making progress.

In proportion as the other great states of Europe improve their natural resources, the importance of Prussia must decline. The time is past when the good order of her finances, and the discipline of her armies, could raise her to an equality with France, and Austria, and Russia; and she can only now support her rank by cultivating still farther those moral advantages which are the real source of her strength.

In 1791 Prussia acquired the principalities of Anspach and Bayreuth; in 1793 a part of Poland containing 1,136,000 inhabitants; and in 1795 an additional part, containing 860,000. At the peace of Luneville in 1801, she gave up some possessions on the left of the Rhine, and received indemnities in Germany, leaving a balance in her favour. These various acquisitions added 46,000 square miles to her territory, and 2,836,000 to her population, raising the former to 116,000 square miles, and the latter to 9,100,000 souls. Such was Prussia in 1803. The ruinous campaign of 1806 suddenly deprived her of all her possessions between the Elbe and the Rhine, with four fifths of her share of Poland, reducing her territory and population about one half, the latter being estimated at 4,560,000 in 1808. On the overthrow of Napoleon in 1814, she was restored to more than her ancient splendour. She recovered the greater part of her Polish dominions, gained some districts in Saxony and Lusatia, Swedish Pomerania, and an extensive, rich, and populous country in Westphalia and on the Rhine, including the greater part of the secularised ecclesiastical states, abbey lands, &c. The Prussian monarchy at present embraces an area of 94,000 square English miles, and a population of 12,464,000.

Russia.

Russia occupies very nearly one half of the surface of Europe; and yet her territories in this division of the globe are scarcely more than one fifth of her whole dominions. Three fourths of her Asiatic territories, however, consist of sandy deserts or frozen plains, which yield very little for human subsistence; and her possessions in Europe are at present, and perhaps will always be, the most valuable part of the empire. European Russia consists chiefly of an elevated plain, over which numerous rivers flow with a small declivity, so as to afford a greater extent of inland navigation, probably, than exists in all the rest of Europe. Its superficial extent, including Poland, is about 1,990,000 square English miles, which is about ten times the area of France, or sixteen times that of the British isles. But of this surface, more than one fourth part, lying beyond the parallel of 60°, is incapable of cultivation, from the rigour of the climate, or the marshy nature of the soil. In the south, also, there are vast sandy plains, the soil of which, destitute of wood and water, and impregnated with salt, is altogether useless for agriculture. The fertile part of Russia consists chiefly of the country lying between the parallels of 50° and 57°, which contains a great proportion of excellent soil, well watered with navigable streams, and comparatively populous and cultivated. The cultivation of wheat is chiefly confined to this region; and here abundant crops are procured with little labour, and by a very rude species of culture. But farther north slender crops are obtained with so much exertion, that a single peasant cannot cultivate more than from seven to ten acres; and these crops are so precarious, that the rye sometimes will not ripen in the neighbourhood of Petersburg. The lands, however, where corn will not grow yield pasture and wood. Trees are found as far as the sixty-seventh degree, beyond which there are only shrubs.[1]

It has been computed that the soil incapable of cultivation in European Russia amounts to forty parts in the hundred of the whole surface. The crown forests are estimated at 44,500,000 of desiatines, equal to 240,000 square miles. Rye is the grain most extensively cultivated all over Russia; but barley, wheat, and oats, are also raised. In the southern provinces, maize, rice, vines, and even cotton, succeed; and both in the southern and central parts, vast ranges of pasture ground support numerous herds of cattle, the skins and tallow of which, with the peltries of wild animals, are leading articles of exportation. These pastures are generally commons: the quantity of uncultivated lands, says Storch, is so great, that it would be useless to divide them. The number of sheep in Russia has been estimated at 60,000,000. Flax and hemp, however, are the productions in which the soil of Russia has the greatest superiority, and of these she exports great quantities. Some of the less civilized nations are almost supported by bees, and wax and honey are also among the principal articles of exportation. Russia has rich mines of gold, silver, copper, iron, lead, and salt, the best of which are in the Uralian Mountains, and chiefly on the Asiatic side. They employ about half a million of persons.

The manufactures of Russia are inconsiderable, though the government has made great exertions to encourage this species of industry. The principal are those of coarse woollens, flax, iron, leather, silk, glass, and brandies. The manufacturing establishments in 1815 amounted to 3262, of which 181 were for cloth, 150 silk, 1348 leather, 247 soap, tallow, and wax, 184 linen, 295 cotton, 138 glass, 200 metal. (Crome, p. 70.)

If confidence might be put in the lists transmitted to government, the annual mortality in Russia is only one in fifty-eight, the births one in twenty-six, and the annual addition to the population one in forty-nine, so that the period of doubling should be thirty-five years. (Storch, i. 282.) But these extraordinary results are irreconcilable with facts. There are in Russia above eighty nations, who speak more than forty different languages; but the Sclavonic race forms seven eighths of the whole European population. According to the official returns in 1783, the peasants belonging to the crown and to the nobles amounted to eighty-three persons in the hundred of the whole population. (Storch, i. 249.) Of all the powers of Europe, Russia is the only one that, during the numerous changes of the last thirty years, has never lost any part of her territories, but has been continually adding to them. Her acquisitions since 1770 are as follows:

	Square Miles.	Population.
1772, First partition of Poland....	33,000	1,226,000
1793, Second do. do........	90,000	3,745,000
1795, Third do. do........	42,000	1,407,000
1774 to 1791, from the Porte....	60,000	204,000
1807, District of Bialystock from Prussia........................	4,200	183,000
1809, District of Tarnopol, ceded by Austria, containing 400,000 inhabitants, but restored in 1815.		
1809, Finland and Lapmark from Sweden....................	120,000	895,000
1811, Part of Moldavia and Bessarabia from the Porte...........	13,000	230,000
1814, Duchy of Warsaw, now the kingdom of Poland..............	47,400	2,793,000
Total acquisitions of Russia since 1770 in Europe.................	409,600	10,683,000

The success of the Parisian insurrection in July 1830 roused the Poles to make a new effort for independence, which began in November 1830, and was finally crushed in the following year, after a heroic resistance. The consequence was, that Poland was deprived of its separate constitution, and incorporated with Russia as an integral part of the empire in February 1832.

SWEDEN.

Sweden has sunk in her relative importance in consequence of the rise of Russia; but she still holds a higher place in the scale of power than any other European state with an equal population. Now that Norway is united to her dominions, she has the best military and commercial position of all the northern continental powers. But the soil is poor and rocky; so that, though her territories form one tenth of the surface of Europe, her population amounts to less than one fiftieth. Her principal wealth consists in her rich mines of iron and copper, and in the produce of her forests and her fisheries.

The agricultural produce of Sweden, which does not suffice for her own consumption, consists chiefly of rye, oats, barley, and potatoes; the soil and climate not admitting of wheat, except in the southern parts. Gothland, the most fertile province, contains one half of the population upon less than one fifth of the surface of the kingdom. The soil actually under corn cultivation in 1810 amounted only to 1,091,000 tunnas, or 1,363,838 acres; but the soil capable of cultivation was estimated at 1,818,450 acres, or one sixty-second part of the surface of the country. This is the average of the whole; but in the province of Nordland only one acre in 915 is arable. The lakes cover one eighteenth part. The pasture ground and gardens occupy about twice the quantity of land under corn. The average size of a farm is only about twenty-seven acres. The whole annual produce of grain is estimated at 5,702,835 spans, equal to about 1,482,500 quarters, besides 350,000 quarters of potatoes. The general produce of the crops is about five for one. In Norway, the land in cultivation amounts to less than one acre in a hundred, and one fourth of the grain used is imported. Potatoes are extensively cultivated. In times of scarcity bread is made of the bark of trees, and of the Iceland moss, on which the rein-deer feed.

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[1] Storch, *Tableau*, i. 4; ii. 209, 229, 231; Crome, *Ubersicht*, 55.

The manufactures of Sweden are of little importance. Sixty or seventy ships are built annually, and sold to foreigners. The distillation of brandy consumes 700,000 spans of corn a year. The manufactures of paper and glass, and works in metal, supply the internal consumption; those of cotton, wool, and silk, are of small extent. The whole produce of manufactures in Sweden (exclusive of Norway), in 1814, was valued, in an official statement, at 5,622,129 dollars banco, or about L.800,000. (Crome, 123.)

The exports of Sweden, in 1816, were estimated at seven millions of dollars (exclusive of Norway), and the imports at no less than twenty millions. The supposed national loss arising from this disproportion led to a prohibition of the importation of wine, rum, cotton stuffs, and other articles considered as luxuries. In 1816, Sweden had 1107 merchant ships, whose aggregate burden was 64,000 lasts, or 120,000 tons. (Crome, 122, 125.)

The population of Sweden was estimated at 2,615,800 in 1818; that of Norway, in 1803, was 910,000; and from the probable rate of increase there, must now amount to fully one million. In Sweden about one ninth, and in Norway about one twelfth of the people live in towns. This increase in numbers has been attended with an improvement in the condition of the inhabitants. The annual mortality in Sweden, which Malthus, in 1796, estimated at one in thirty-seven, was, in 1811, according to Akrell, one in forty for the southern parts, one in forty-seven for the northern, and one in forty-three for the whole kingdom. In Norway the mortality has always been smaller than in any other European country. In 1815 the nobles amounted to 1641 families, or 9523 persons; the clergy, including their families, to 15,202; the burghers to 64,755; and the peasants to 1,763,397. Besides these classes, who are represented in the diet, there are about 500,000 persons not represented, consisting of civil and military officers, miners, mechanics, servants, &c. About one fourth of the peasants who are householders, farm their own lands. The established religion is Lutheran, and the number of parochial clergymen in Sweden is 1094, besides 170 prebends, eleven bishops, and one archbishop; and the tithes amount to 283,232 spans, or about 72,500 quarters of corn. Norway has 467 clergymen, including five bishops. (Crome, 96, 116; Thomson's *Travels*, 418.)

Subsequent to the revolution in 1809, some improvements have been made in the constitution, by enlarging the powers of the diet. The four estates of nobles, clergy, burghers, and peasants, who sit in separate houses, meet necessarily at the end of five years, or oftener if convoked by the king. The consent of three of these houses, with that of the king, gives a proposition the force of law. No taxes can be raised without the authority of the diet, and the persons of the members are inviolable during the session. The conscription, which was introduced in 1809, subjects all males between twenty and twenty-five to military service; and the nobles have been deprived of the exemption they formerly enjoyed from this service and from taxes. The press is declared by the constitution to be free, but is in fact under the control of the police.

In 1809, Sweden lost Finland, Lapmark, and Pomerania, containing 1,015,000 inhabitants, upon a surface of 121,000 square miles. In 1813, she gained Norway from Denmark, with 950,000 inhabitants. This acquisition gave her a better frontier and a more compact territory, and was more than a compensation for her previous losses.

SPAIN.

The vast natural resources of this country present a striking contrast with its political imbecility. It is nearly as large as France, but contains little more than a third of the population, though its fertile soil and delicious climate yield in abundance the productions both of the temperate and warm regions of the globe. With its great extent of sea-coast, numerous rivers, and excellent position for trade, and its rich and extensive colonies, nothing but extreme misgovernment could have prevented it from becoming the first commercial state in the world.

In addition to silk, tobacco, vines, olives, and all the agricultural productions of France and Germany, Spain produces the orange, citron, sugar-cane, cork-tree, dates, figs, and cotton. Wheat is the grain most extensively cultivated. Barley and rye are next in quantity. Very few oats or potatoes are raised, but considerable quantities of maize and rice. Hemp to the value of a million of piastres is raised yearly, and flax is cultivated on a smaller scale. The vineyards, besides supplying the internal consumption, furnish 10,000,000 or 11,000,000 gallons of wine for exportation, and half as much brandy. Olive oil is exported to the value of L.600,000 a year. The annual produce of raw silk is valued at L.300,000. But wool is the produce for which Spain is most celebrated. The number of merinos or migratory sheep, which furnish the finest wool, is estimated at 5,000,000; those that are stationary, at 8,000,000; and these 13,000,000 of sheep are supposed to afford yearly 45,000,000 pounds of wool. The right of pasture which the migratory flocks have over whole provinces is one great obstacle to agricultural improvement. From this and other causes, one third or one half of the kingdom is left entirely waste, and the part in cultivation is wretchedly managed. Nearly the whole land in the kingdom is locked up by entails in the hands of the nobles and the clergy, and the small portions brought into the market sell so high as not to afford more than one and a half per cent. upon their price. Agriculture is entirely in the hands of the peasantry, who are poor and ignorant; men of capital never engage in it; and the grandees, who should support and encourage improvements, all reside in the large towns. In the whole of Spain there is scarcely to be seen a villa or gentleman's seat, except a few that are in ruins. The mines of Spain, like her agriculture, are neglected; but she still derives from her own soil a considerable supply of iron, copper, lead, and mercury. About 5,000,000 centners of salt are annually obtained from mines, springs, or the sea.

The greatest number of the Spanish manufactures are in Catalonia, but a few are scattered through the other provinces. The most considerable are the woollen, silk, linen, cotton, hemp, leather, paper, and metal; but none of them are sufficient for the internal consumption of the country, and all of them are fettered by vexatious taxes, absurd regulations, and the difficulty of intercourse between the provinces. The manufacture of tobacco is a royal monopoly.

It is now pretty well ascertained, that the apparent decline of Spain has been the consequence of the rapid progress of her neighbours; and that, down to the end of the eighteenth century, she was advancing both in industry and population. From a combination of circumstances, the causes which check the progress of society have operated more powerfully there than in any other country of Europe except Turkey. Among the greatest evils in the state of the country may be reckoned the excessive number of the nobility and clergy, with their oppressive privileges, and their pernicious influence upon the other classes. In 1788, when the population amounted to

10,500,000, the number of the secular and regular clergy was 147,722, of the nobles 478,716, of peasants and labourers 1,847,010, of manufacturers and handicrafts 302,000, servants 276,090, merchants 34,030.

GERMANY.

In the early part of the eighteenth century, Germany consisted of about three hundred sovereign states, great and small, which were united into one empire by a very complicated constitution. From time to time some of the smaller principalities have been suppressed, and incorporated with the larger states: but the first radical change in the composition of the Germanic body was made by the treaty of Luneville, 9th February 1801, when a vast number of bishoprics, abbeys, and free towns, were deprived of their rights of sovereignty, and given as indemnities to princes who had lost their possessions in Belgium and Italy by the French conquests. In 1806 the emperor Francis formally renounced the dignity of head of the empire; the ancient constitution of the empire was dissolved, and a new league formed, with France at its head (see CONFEDERATION OF THE RHINE), comprehending the most considerable states in the south, to which those in the north were afterwards added. This confederation fell to pieces on the overthrow of the French power in 1813, but it has served as the foundation of the new constitution of the Germanic body. The number of states is now reduced to thirty-nine, including Austria, Prussia, Denmark, and the Netherlands; but these four powers rank as members only for a part of their dominions. The ecclesiastical principalities are entirely abolished; and the free towns, of which there were forty-seven or more in 1800, are now reduced to four. The princes who have lost their sovereignty have been reduced to the rank of nobles, and, no longer holding immediately of the empire, are said to be *mediatised*. The titles of royalty conferred by Bonaparte upon Bavaria, Wirtemberg, and Saxony, have been confirmed, and Hanover has since been raised to the same rank. The common concerns of this confederacy are managed by a diet, consisting of deputies from thirty-eight states (Hesse Homberg having no vote), who meet at Frankfort. The pecuniary contributions, fixed in proportion to the population of each state, are voted for a period of five years. The military contingents, which are regulated on the same principle, amount to 120,000 men in time of peace, and 301,000 in time of war, the latter being at the rate of one in the hundred of the population. The German states, including two sevenths of Austria, four sevenths of Prussia, besides Holstein and Luxemburg, embrace an area of about 237,000 English square miles, with 32,000,000 inhabitants; of whom about one half are Catholics; two fifths Lutherans; the rest Reformed, Moravians, Greeks, and Jews. The new Germanic constitution, though less complicated than the old, can scarcely be expected to produce any of the effects of a solid union in such a heterogeneous mass. The states are too unequal in strength to have a proper reciprocal influence; and there is not weight enough in the minor members to control the rival interests and jealousies of Austria and Prussia. The confederation may be considered as recognising, and in some degree regulating, the influence which the greatest states must necessarily exercise indirectly over the smaller.

The following table exhibits the result of the various changes since the commencement of the French Revolution, upon the principal members of the confederation; but to enter into particulars would carry us beyond the proper limits of this article. Most of them, except Saxony, have been enriched by the breaking up of the ecclesiastical principalities.

	Before the Revolution.		In 1816.	
	Square Miles.	Population.	Square Miles.	Population.
Bavaria	22,000	2,183,000	30,000	3,560,000
Saxony	14,800	2,104,000	7,200	1,200,000
Hanover	10,900	787,000	14,400	1,305,000
Wirtemberg	3,200	608,000	8,200	1,395,463
Baden	1,370	177,000	5,800	1,001,700
Hesse Cassel	3,340	443,500	4,300	540,000
Hesse Darmstadt	2,180	249,700	4,100	619,500
Oldenburg	960	95,000	2,500	217,000

(Hoeck, *Aperçu ;* Hassel, *Europ. Staats*, 1816).

The political arrangement of the states of Europe established by the peace of 1815, has since undergone three material alterations. The Greeks rose in arms against the Porte in 1821, and after a struggle of nine years, the independence of their country was acknowledged by the sultan in February 1830. The new state comprises the Morea, Livadia, Negropont, the Cyclades, with one or two other islands, and contains a population, according to Balbi, of only 600,000 souls. Otho, second son of the king of Bavaria, was appointed king of Greece in 1832.

The mutual antipathy which had long existed between the Dutch and Belgians broke out on the part of the latter into a revolutionary movement, which commenced in Brussels in August 1830, and in a few months spread over all Belgium. The independence of the latter country has since been acknowledged by nearly all the great powers; and Prince Leopold of Saxe Cobourg was chosen king in 1831 by an assembly of the representatives of the people.

The third change has been already noticed, the incorporation of Poland with Russia in February 1832.

The following statistical table of Europe is part of a larger one published at Paris by Adrien Balbi in 1828, under the title of *Balance Politique du Globe.* He has reprinted it in his *Abrégé de la Geographie*, published in 1833, with very few alterations except the insertion of the new states since recognised, namely, Greece and Belgium. It refers to the years 1826–27, his object being not to give the most recent accounts for each state, which must have varied according to the varying dates of our information, but to exhibit the contemporaneous condition of all the states at one common era, for the purpose of comparison. It presents the most correct view of the statistics of Europe within our reach; and what we have mentioned as to the author's mode of compiling it, and his object, will explain the discrepancies between it and some of our previous statements.

States and Titles.	Surface in Square Miles.	Population.	Classification of the Inhabitants according to their Religion.	Revenue in Pounds Sterling.	Debts in Pounds Sterling.	Army.
French Monarchy	205,000	32,000,000	Catholics, Calvinists, Lutherans, Jews	40,784,000	190,680,000	279,900
Empire of Austria	258,000	32,000,000	Catholics, Greeks, Calvinists, Lutherans, Jews, Unitarians, Arminians, &c.	18,600,000	68,206,000	271,400
Prussian Monarchy	107,000	12,464,000	Evangelists (Lutherans, Calvinists), Catholics, Jews, Mennonites, &c.	8,866,000	29,966,000	162,600
Swiss Confederation	14,900	1,980,000	Calvinists, Catholics, Jews	412,000	......	33,759
K. of Bavaria	29,500	4,070,000	Catholics, Evangelists, Jews	3,262,000	9,823,000	35,800
K. of Wirtemberg	7,600	1,520,000	Lutherans, Catholics, Jews, Calvinists	980,000	2,330,000	13,955
K. of Hanover	14,800	1,550,000	Lutherans, Catholics, Calvinists, Jews	1,072,000	2,640,000	13,054
K. of Saxony	5,780	1,400,000	Lutherans, Catholics, Hernhutters, Jews	1,155,000	2,887,000	12,000
Gr. D. of Baden	5,970	1,130,000	Catholics, Lutherans, Calvinists, Jews	839,000	1,609,000	10,000
Gr. Duke of Hessen	3,760	700,000	Luther. Cath. Calv. Jews, Mennonites	648,000	1,114,000	6,195
Electoral Hessen	4,450	592,000	Evangelists, Catholics, Jews	639,000	272,000	5,679
Gr. D. of Saxe-Weimar	1,420	222,000	Lutherans, Catholics, Calvinists, Jews	203,000	672,000	2,100
Gr. D. of Mecklenb. Schwerin	4,770	431,000	Lutherans, Jews, Catholics, Calvinists	247,000	1,010,000	3,580
Gr. D. of Mecklenb. Strelitz	770	77,000	Lutherans, Jews	54,000	124,000	717
Gr. D. of Holstein-Oldenburg	2,500	241,000	Lutherans, Catholics, Calvinists, Jews	160,000	......	1,650
D. of Nassau	1,925	337,000	Evangelists, Catholics, Jews, &c	247,000	446,000	3,028
D. of Brunswick	1,500	242,000	Lutherans, Catholics, Calvinists, Jews	260,000	330,000	2,090
D. of Saxe-Coburg-Gotha	974	143,000	Lutherans, Catholics, Calvinists, Jews	101,000	289,000	1,394
D. of Saxe-Meiningen	921	130,000	Lutherans, Jews, Catholics	80,000	83,000	1,268
D. of Saxe-Altenburg	528	104,000	Lutherans	63,000	103,000	1,026
D. of Anhalt-Dessau	347	56,000	Calvinists, Lutherans, Jews, Catholics	76,000	86,000	529
D. of Anhalt-Bernburg	337	38,000	Calvinists, Lutherans, Jews	48,000	86,000	370
D. of Anhalt-Kœthen	320	34,000	Calvinists, Lutherans, Jews	34,000	128,000	324
P. Schwarz-Rudolstadt	408	57,000	Lutherans, Catholics	35,000	39,000	539
P. Schwarz-Sondershausen	360	48,000	Lutherans, Catholics	21,000	13,000	451
P. Reuss-Greiz	145	23,000	Lutherans, Jews	15,000	22,000	206
P. Reuss-Schleiz	208	28,000	Lutherans, Hernhutters, Jews	14,000	75,000	280
P. Reuss Lobenst.-Ebersdorf	242	26,000	Lutherans	26,000		260
P. Lippe-Detmold	440	72,000	Calvinists, Lutherans, Catholics	53,000	75,000	690
P. Lippe-Schauenburg	209	26,000	Lutherans, Calvinists, Catholics	23,000	43,000	240
P. Waldeck	462	54,000	Lutherans, Calvinists, Jews	43,000	128,000	518
P. Hohenzoll.-Sigmaringen	390	38,000	Catholics, Jews	32,000	160,000	320
P. Hohenzollern-Hechingen	109	15,000	Catholics	13,000	53,000	145
P. Liechtenstein	53	6,000	Catholics	144,000	322,000	55
Landgrav. Hessen-Homburg	166	20,000	Calvinists, Lutherans, Catholics, Jew	19,000	48,000	200
Republic of Frankfort	92	52,000	Lutherans, Catholics, Jews, Calvinists	81,000	853,000	473
Republic of Bremen	68	49,000	Lutherans, Calvinists	43,000	322,000	385
Republic of Hamburg	152	148,000	Lutherans, Jews, Calv. Cath. Mennonites	231,000	1,938,000	1,298
Republic of Lubec	117	41,000	Lutherans, Catholics, Jews, Calvinists	43,000	371,000	406
Lordship of Kniphausen	17	2,859	Lutherans	16,000	......	28
Republic of Andora (in Spain)	192	15,000	Catholics	......	......	......
Republic of San-Marino	22	7,000	Catholics	2,900	......	40
Duchy of Massa	94	29,000	Catholics	21,000	62,000	100
Duchy of Modena	2,000	380,000	Catholics, Jews	144,000		1,680
Principality of Monaco	50	6,500	Catholics	17,000	......	......
Duchy of Lucca	416	143,000	Catholics	78,500	......	800
Duchy of Parma	2,200	440,000	Catholics	190,000	186,000	1,320
Grand Duchy of Tuscany	8,430	1,275,000	Catholics, Jews	701,000	......	4,000
Kingdom of Sardinia	28,000	4,300,000	Catholics, Calvinists (Waldenses), Jews	2,800,000	4,124,000	26,000
State of the Church	17,000	2,590,000	Catholics, Jews	1,800,000	24,742,000	6,000
Kingdom of the Two Sicilies	42,300	7,420,000	Catholics, Jews	3,464,000	20,619,000	30,000
Spanish Monarchy	183,000	13,900,000	Catholics	7,100,000	164,948,000	50,000
Portuguese Monarchy	38,800	3,530,000	Catholics	2,231,000	6,598,000	26,636
Norwegio-Swedish Monarchy	297,000	3,866,000	Lutherans, Catholics, Jews	1,732,000	8,248,000	45,200
Danish Monarchy	22,000	1,950,000	Lutherans, Jews, Catholics, Calvinists, &c.	1,650,000	11,134,000	38,849
Holland	11,100	2,302,000	Calvinists, Catholics, Lutherans	3,400,000	113,420,000	26,000
Belgium	12,930	3,816,000	Catholics, Calvinists	3,600,000	34,000,000	47,000
English Monarchy	121,200	23,400,000	Anglicans or Episcop. Cath. Presb. Methodists, Mennonites, Quakers, Jews	63,000,000	838,967,000	102,283
Russian Empire	1,997,000	52,575,000	Greeks, Catholics, Lutherans, Mahommedans, Jews, Calvinists, Armenians, Lamists, Hernhutters, Fetichists, Mennonites	16,495,000	55,608,000	1,039,000
Kingdom of Poland	48,800	3,900,000				
Total of the Russian Empire	7,880,000	60,000,000				
Republic of Cracow (in Poland)	496	114,000	Catholics, Jews, Lutherans	36,000	......	80
European Turkey	206,000	9,500,000	Greeks, Mahommedans, Jews, Catholics, Armenians, &c.	10,310,000	4,124,000	278,000
Total of Ottoman Empire	1,200,000	21,000,000				
Greece (kingdom of)	15,700	600,000	Greeks, Catholics	240,000	2,800,000	11,000
Republic of the Ionian Islands	1,000	176,000	Greeks, Catholics, Jews	151,000	......	1,200

EURYALE, in *Mythology*, one of the Gorgons, daughters of Phorcys, and a sister of Medusa, who was subject neither to old age nor to death.

EURYDICE, in fabulous history, the wife of Orpheus, who flying from the attempted ravishment of Aristæus, was slain by a serpent. Her husband went down to the shades, and by the force of his music persuaded Pluto and Proserpine to allow him to carry back his wife to earth, a favour which they granted, provided he did not look on her till he reached the light; but in a moment of affection and forgetfulness he broke the condition, and Eurydice vanished from his sight.

EURYMEDON, in *Ancient Geography*, a noble river running through the middle of Pamphylia, and celebrated for a sea and land fight which took place on the same day, and in which the Athenians, under Cimon the son of Miltiades, defeated the Persians.

EURYSTHEUS, a king of Argos and Mycenæ, son of Sthenelus, and Nicippe the daughter of Pelops. Juno hastened his birth by two months, that he might come into the world before Hercules the son of Alcmena, as the younger of the two was doomed by order of Jupiter to be subservient to the will of the other. This natural right was cruelly exercised by Eurystheus, who was jealous of the fame of Hercules; and who, in order to destroy so powerful a relation, imposed upon him the most dangerous and uncommon enterprises, well known by the name of the labours of Hercules. The success of Hercules in achieving these perilous labours having greatly alarmed Eurystheus, he furnished himself with a brazen vessel, in which he might secure himself a safe retreat in case of danger. After the death of Hercules, Eurystheus renewed his cruelties against the children of the hero, and made war against Ceyx, king of Trachinia, because he had given them support, and treated them with hospitality. But he was killed in the prosecution of this war by Hyllus, the son of Hercules, and his head was sent to Alcmena, the mother of Hercules, who, mindful of the cruelties which her son had suffered, insulted it, and tore out the eyes with inveterate fury. Eurystheus was succeeded on the throne of Argos by Atreus his nephew. The death of Eurystheus happened about thirty years before the Trojan war.

EUSEBIANS, a denomination given to the sect of Arians, on account of the favour and countenance which Eusebius, bishop of Cæsarea, showed for them at their first rise.

EUSEBIUS, surnamed PAMPHILUS, a celebrated bishop of Cæsarea, in Palestine, and one of the most illustrious men of the Christian church, was born in Palestine, towards the close of the reign of Gallienus, about the year 267 of our era. He was the intimate friend of Pamphilus, who suffered martyrdom under Diocletian in 309, and, after his death, took his name in honour of his memory. He was ordained bishop of Cæsarea in 313. He had a considerable share in the contest relating to Arius, whose cause he, as well as several other bishops of Palestine, defended, being persuaded that Arius had been unjustly persecuted by Alexander, bishop of Alexandria. He assisted at the council of Nice in 325, when he made a speech to the emperor Constantine on his coming to the council, and was placed next to him on his right hand. In 330 he was present at the council of Antioch, in which Eustathius, bishop of that city, was unjustly deposed; but though he was chosen by the bishop and people of Antioch to succeed that prelate, he absolutely refused. In 334 he assisted at the councils of Cæsarea and of Tyre, by which Athanasius was condemned; and he was present at the assembly of bishops at Jerusalem during the dedication of the church in that city. By these bishops he was sent to the emperor Constantine to defend what they had done against Athanasius; when he pronounced the panegyric composed on that emperor during the public rejoicings in the beginning of the thirtieth year of his reign. Eusebius survived the emperor but a short time, and died in 338. Ecclesiastical writers, ancient and modern, are much divided in opinion respecting Eusebius. Several have defended him with warmth, in which number are Sozomenes, Socrates, Victorius, and some others. St Jerome, on the other hand, calls him the prince of Arians, Photius accuses him, the seventh council condemns him, and this opinion is generally followed by the moderns. The successor of Eusebius was Acacius, surnamed the One-eyed, a man not less learned or less eloquent, and more enterprising, than his master. Eusebius composed in Greek a multitude of works filled with eloquence and erudition; and those which have reached us, whilst they justify the high reputation of the author, cannot fail to occasion regret that so many have perished. He wrote, 1. the *Apology* or Defence *of Origen*, in six books; 2. a *Treatise against Hierocles;* 3. Fifteen books of *Preparationes Evangelicæ*, and twenty *De Demonstratione Evangelica;* 4. A *Chronicle* from the beginning of the world till the twentieth year of Constantine; 5. An *Ecclesiastical History*, of which Valetius published a good edition in Greek and Latin; 6. A *Paschal Cycle;* 7. A work against Marcellus of Ancyra, who was condemned at the council of Constantinople in 335 and 336; 8. Four books of the *Life of Constantine;* 9. Five books on the *Incarnation;* 10. Ten books of Commentaries on Isaiah; 11. Thirty books against Porphyry; 12. a book of *Topics;* 13. A *Nomenclature of Peoples and Nations*, according to the books of the Hebrews; 14. A *Topography of Judæa and the Temple;* 15. Three books of the *Life of Pamphilus;* 16. *Opuscula* on the Martyrs; 17. *Commentaries on the Psalms*; 18. A *Letter to Caspianus*, and a *Concordance of the Four Evangelists.* It appears also that he wrote a *Commentary on the first Epistle to the Corinthians*, and a *Treatise on the Accomplishment of the Predictions of Jesus Christ.* The greater number of his works, however, is only known by the testimony of St Jerome, who makes frequent mention of them, cites fragments of them, and appears to have used them very freely in the composition of his own works. Of those which have come down to us, the most considerable is the *Ecclesiastical History*, which has been translated into Latin by Rufinus, by Musculus, and by Christopherson. The version of the last-mentioned translator, printed opposite the Greek text, appeared in 1612. This work of Eusebius is of the greatest utility in reference to the history of the Christian church during the first three centuries, and it has earned for its author the honourable title of Father of Ecclesiastical History. In his *Chronicle*, which contains the principal actions of great men, and the history of discovery in the arts, Eusebius is supposed to have availed himself of the Chronology composed a century before by Julius Africanus. St Jerome translated the Chronicle into Latin, and continued it till the sixth consulate of Valens and Valentinian. The four books of the Life of Constantine have been printed with the Ecclesiastical History, and translated into French by Cousin. The ten books which remain of the *Preparatio Evangelica* and the *Demonstratio* were published at Paris in 1627, with the versions of Donatus and Vigerus, to which was subjoined the Treatise against Hierocles. It is in the *Demonstratio* that the invaluable fragment on Sanctification is contained. The Topography of the Holy Land, which St Jerome translated into Latin, was published in Greek by Bonfrère in 1631: it is also found in several editions of the works of St Jerome. The Commentary on the Psalms was published by Montfaucon; the *Opuscula* in Latin by Sirmond; the Letter to Caspianus and the Canons for a Concordance of the Gospels in the edition of the Greek New Testament, by Robert Estienne, 1550; the Notes on the Canticles by Meursius; and the fragments on the Lives of the Prophets by Curlerius, in his *Commentaries of Procopius on Isaiah.*

EUSTATHIANS, a name given to the Catholics of Antioch in the fourth century, on occasion of their refusal to acknowledge any other bishop except Eustathius, who had been deposed by the Arians. This denomination was given them during the episcopate of Paulinus, whom the Arians substituted instead of Eustathius, about the year 330, when they began to hold their assemblies apart. About the year 350, Leontius of Phrygia, surnamed the Eunuch, who was an Arian, and was put in the see of Antioch, desired the Eustathians to perform their service in his church; which offer they accepted, and the church of Antioch served indifferently both Arians and Catholics. This, we are told, gave occasion to two institutions, which have ever since subsisted in the church; the first, psalmody in two choirs; and the second, the doxology.

This conduct, which seemed to imply a kind of communion with the Arians, gave great offence to many of the Catholics, who began to hold separate meetings; and hence arose the schism of Antioch. Upon this, the rest, who continued to meet in the church, ceased to be called Eustathians, and that appellation was restricted to the dissenting party. Flavianus, bishop of Antioch, in 381, and one of his successors, Alexander, in 481, brought about a coalition or reunion between the Eustathians and the body of the church of Antioch, which is described with much solemnity by Theodoret (*Eccl.* lib. iii. c. 2.)

EUSTATHIANS were also a sect of heretics in the fourth century, who derived their name from their founder Eustathius, a monk, who was so foolishly fond of his own profession, that he condemned all other conditions of life. But whether this Eustathius was the same with the bishop of Sebastia and the chief of the Semi-Arians, is not easy to determine.

Eustathius excluded married people from salvation, prohibited his followers from praying in their houses, and obliged them to quit all they had, as incompatible with the hopes of heaven. He drew them out of the other assemblies of Christians, to hold secret meetings with him, and made them wear a particular habit; he ordained them to fast on Sundays; and he taught them, that the ordinary fasts of the church were needless, after they had attained to a certain degree of purity which he pretended to. He evinced great horror of chapels built in honour of martyrs, and of the assemblies held therein. Several women, seduced by his reasoning, forsook their husbands, and abundance of slaves deserted their masters' houses. He was condemned at the council of Gangra in Paphlagonia, which was held between the years 326 and 341.

EUSTATHIUS, archbishop of Thessalonica, and commentator on Homer, flourished at Constantinople in the twelfth century. Before his promotion to the see of Thessalonica, he was master of requests and master of orators, two ecclesiastical offices, the latter of which (namely, that of the orators or *rhetores*) had for its object to expound the sacred writings to the people. It was during this first part of his public career that he wrote his commentaries on Homer and on Dionysius Periegetes. His remarks on Dionysius have been frequently printed along with the text of that author, and Politi has given a Latin translation of them, Geneva, 1741, in 8vo. But these, however useful and deserving of commendation, are in no degree comparable to the *Commentaries* on the Iliad and Odyssey, which embody an immense treasure of literary and grammatical erudition, chiefly extracted and compiled from preceding scholiasts and commentators, as Apion, Herodorus, Demosthenes of Thrace, Porphyry, and some others, the additions made to their observations by Eustathius himself being neither very considerable nor very important. To these *Commentaries*, as well as to his *Annotations* on Dionysius, the learned commentator has given the modest title of *Parecbolæ* or Extracts; desirous, no doubt, that those who might neglect to read his preface should learn from the title alone the nature of his work, and thus be prevented from attributing a disproportionate share of merit to the compiler. The commentaries of Eustathius on the Iliad were printed for the first time at Rome, 1542–1550, in four vols. folio, including the beautiful table of Devaris. But as this edition is exceedingly scarce and high-priced, that of Bâle, printed by Froben, 1559–1560, in three vols. folio, which is the next in point of authority, may be advantageously consulted by scholars, in default of the former. It must not be confounded, however, with an *Abridgment* of Eustathius, of which Hadrian de Jonghes was editor, and which appeared at Bâle, from the press of the same Froben, 1558, in one volume. Claude Capperonier, who had promised a new Greek and Latin edition of the *Commentaries* of Eustathius, died without having published any part of it; but Politi, whom we have already named, undertook this great work, of which he published at Florence, 1730–1735, three vols. folio, containing the first five books of the Iliad. It is to be regretted, however, that Politi took the trouble to translate into Latin a work which is only suitable to those who are deeply versed in the Greek language, and for whom the aid of a translation is superfluous; and it was probably this useless addition which caused the interruption of the enterprize. With reference to the extracts from the Commentaries of Eustathius which Müller and Clarke have given in their respective editions of the Iliad, it is only necessary to mention here, that these have, in each case, been made upon a principle of selection adapted to the peculiar nature and object of the undertaking. It is of more importance to observe, that at the period when Eustathius lived original literature had almost disappeared, and that consequently this vast and important compilation secured to him an immense reputation. Intended at first for the bishopric of Myra in Lycia, he was soon afterwards appointed archbishop of Thessalonica, and in the exercise of his high functions displayed a dignified and respectable character. The year of his death is unknown; but he was alive in 1194, and it may be conjectured that he died after 1198, at a very advanced age. Eustathius appears, from his Notes on the *Canons* of Joannes Damascenus, to have composed several works besides those which we have already mentioned; particularly a Commentary on Pindar, which is almost entirely lost; Homilies, Discourses, Remarks on the Canons of St John of Damascus, and Letters which are preserved in different libraries. Manutius has also inserted in the *Gardens of Adonis* a little treatise of Eustathius on the dialects of Homer, but this tract is merely an insignificant extract from the grammatical observations contained in that Life of Homer which some attribute to Plutarch, and others to Dionysius of Halicarnassus.

EUSTATIA, ST, one of the Leeward Islands, in the West Indies. It is a high rock, rising from the waves in the form of a pyramid, gradually tapering to the top. It is twenty-nine miles in circumference at the base, and, notwithstanding the singular conformation of the island, the climate is healthy, and the soil, which is cultivated to the very summit, most prolific. It is, however, like other islands in this region of the globe, subject to the desolating visitation of thunder-storms and hurricanes. The latter are most to be dreaded during the months of August and September; and they have been frequently so severe as to lay waste the island and scatter the shipping. There is only one landing-place, and that, though difficult of access, is strongly fortified;

indeed the whole island has been rendered nearly impregnable when properly garrisoned. Sugar, cotton, and maize are here produced; but the vegetable production most cultivated is tobacco. Small as this island is, it is said to support nearly twenty thousand inhabitants, who, besides their agricultural avocations, rear hogs, kids, rabbits, and all kinds of poultry, with which they are enabled to serve their neighbours after having supplied themselves. This island was settled by the Dutch as early as the beginning of the seventeenth century; but in 1665 it was taken by the British, who in their turn were ejected by the French. In 1781 it yielded to Admiral Rodney; from the English it was again wrested by the French, and after repeatedly changing masters according to the varying fortunes of war, it was finally transferred to the Dutch government at the peace of 1814. St Eustatia lies fifteen miles south of Saba, and eight miles north-west of St Christophers. Long. 63. 5. W. Lat. 17. 31. N.

EUSTYLE, in *Architecture*, a sort of building in which the pillars are placed at the most convenient distance from one another, the intercolumniations being two diameters and a quarter of the column, excepting those in the middle of the face, before and behind, which are three diameters apart.

EUTERPE, one of the Muses, daughter of Jupiter and Mnemosyne, who presided over music, and was also regarded as the inventress of the flute. She is represented as crowned with flowers, and holding a flute in her hands. Some mythologists attribute to her the invention of tragedy, which is more commonly supposed to be the production of Melpomene.

EUTHYMIA, among the Greeks, signified such a disposition or state of the mind as could not be ruffled either by good or bad fortune, by health or sickness, pleasure or pain, good or evil.

EUTIN, a city in that part of the duchy of Oldenburg which lies on the Baltic Sea, called the duchy of Lubec. It is situated on a beautiful lake, and is surrounded by the Danish province of Holstein. It contains, besides the ducal palace, 260 houses and 2540 inhabitants. Long. 10. 51. E. Lat. 54. 8. N.

EUTROPIUS, FLAVIUS, a Latin historian, of whose life we know but little. Even the prænomen Flavius is uncertain, as well as the race from which he sprung. Some consider him as a native of Italy, others of Gaul, and others again of Constantinople, without our possessing any certain grounds to enable us to decide on the one more than the other. We know that he lived under Constantine Epistolaris, afterwards accompanied Julian against the Persians, and also lived under Valens. But it is uncertain whether the Eutropius named as proconsul of Asia, and another who was præfectus prætoris 381 A. D. be the same person as the historian. His death took place probably in the wars of Valens, and before the death of Sapor, 370 A. D. Eutropius left an epitome of Roman history (*Breviarium Historiæ Romanæ*) in ten books, from the building of Rome to the reign of Valens. At the conclusion he promises a work on the same subject in a more extended form, in consequence of a wish expressed by the emperor, to whom it is dedicated; but we are unable to state whether he put his intentions into execution. The epitome has been generally extracted from sources worthy of credit, from some indeed to which we have no longer access. It carefully omits, however, all that may appear prejudicial to Rome: it follows generally a chronological order. The style is unadorned and simple; and we need not be surprised if he exhibits traces of the corruption of the age in which he lived, and that some of his expressions are less refined than what are found in classical writers. There were two translations of it into Greek, of which the one by Capito Lycius, in the time of Justinian, has perished; but the other, by a certain Pœericus, is still preserved. See Voss. *De Hist. Lat.* ii. 8; Fabric. *Biblioth. Lat.* iii. 9; Moller, *Dissert. de Eutrop.* Altorf, 1685; Tzschucke, *Diss. de Vita*, &c. in his edition of the work, Lips. 1796; Bähr, *Geschichte der Romischen Literatur*, Carlsruhe, 1832.

EUTYCHIANS, ancient heretics, who denied the double nature in Christ, and were so denominated from Eutyches, the archimandrite, or abbot of a monastery at Constantinople, who began to propagate his opinion in the year 448. This man, however, did not seem quite steady and consistent in his sentiments, for he appeared to allow of two natures, even before the union; a consequence he apparently drew from the principles of the Platonic philosophy, which supposes a pre-existence of souls. Accordingly, he believed that the soul of Jesus Christ had been united to the divinity before the incarnation; but then he allowed no distinction of natures in Jesus Christ after his incarnation. This heresy was first condemned in a synod held at Constantinople by Flavian, in 448, the proceedings of which were approved by the council of Ephesus, called *conventus latronum*, in 449, and re-examined and condemned in the general council of Chalcedon in 451. The legates of Pope Leo, who assisted at the latter, maintained that it was not enough to define that there were two natures in Jesus Christ; but insisted strenuously, that, in order to remove all equivocations, they must add these terms, "without being changed, or confounded, or divided."

The heresy of the Eutychians, which made great progress throughout the East, at length became divided into several branches. Nicephorus makes mention of no fewer than twelve; some called *Schematici*, or *Apparentes*, as only attributing to Jesus Christ a phantom or appearance of flesh; others, *Theodosians*, from Theodosius, bishop of Alexandria; others, again, *Jacobites*, from one *Jacobus* of Syria, which last branch established itself principally in Armenia, where it still subsists. Others were named *Acephali*, headless, and *Severians*, from a monk called Severus, who seized on the see of Antioch in 513. These last were split into five subdivisions, namely, *Agnoetæ*, who attributed some ignorance to Jesus Christ; the followers of Paul; Μελαινοι, or the black *Angelites*, so called from the place where they were assembled; and lastly, *Adrites* and *Cononites*.

EUTYCHIANS was also the name of another sect, half Arian half Eunomian, which arose at Constantinople in the fourth century.

It being then a matter of great controversy amongst the Eunomians at Constantinople, whether or not the Son of God knew the last day and hour of the world, particularly with regard to a passage in the gospel of St Matthew (chap. xxiv. ver. 36), or rather to one in St Mark (xiii. 32), where it is expressed that the Son did not know it, but the Father only; Eutychius made no scruple to maintain, even in writing, that the Son did not know it: and this opinion having displeased the leaders of the Eunomian party, he separated from them, and made a journey to Eunomius, then in exile, who fully acquiesced in Eutychius's doctrine, and admitted the latter to his communion. But Eunomius having died soon afterwards, the chief of the Eunomians at Constantinople refused to admit Eutychius; who, upon this, formed a sect of such as adhered to him, who were called *Eutychians*.

This Eutychius, with one Theophronius, were the occasion of all the changes made by the Eunomians in the administration of baptism; which, according to Nicephorus, consisted in only using one immersion, performed not in name of the Trinity, but in memory of the death of Jesus Christ. Nicephorus calls the chief of that sect, not *Eutychius*, but *Eupsychius*, and his followers *Eunomiaupsychians*.

EUTYCHIUS, patriarch of Alexandria, lived about the ninth century; and wrote annals in the Arabic language, printed at Oxford in 1658, with a Latin version by Pococke. Selden had printed something of his before.

EUXINUS PONTUS, Black Sea, lying between Europe and Asia, into which several of the largest rivers in the world flow; on the west the Danube, Dniester, and Dnieper, on the east the Phasis, and on the south the Helys and Thermodon. A large peninsula stretches into the centre, and divides it into two great gulfs; the cape in the Crimea was called Criu-metopon (*Karadje-Bouroun*,), and that in Asia, Carambis (*Kerempi-Bouroun*), being distant from each other 170 miles. According to Strabo, its circumference was 25,000 stadia, equal to 715 leagues, which is very nearly correct. The ancients believed that at one time it had no communication with the Mediterranean, but that the rivers which flow into this sea having opened for themselves a passage, the waters rushed into the Mediterranean by the Hellespont, and caused that sea to burst a passage through the Straits of Gibraltar. (Strab. i. 49.) In the time of Diodorus the inhabitants of the island Samothrace preserved the recollection of an inundation which had elevated the waters of the Mediterranean to such a height that their ancestors were obliged to take refuge on the summits of their highest mountains; and so late as the first century of the Christian era they had the custom of sacrificing on altars placed on the spot to which they believed the waters to have risen. There seems every reason to believe that the Black Sea, Caspian, and Aral, were once united, and perhaps found a vent to the North Sea by the valley through which the river Oby flows from Tobolsk. This immense lake was bounded to the north by the lofty mountains of Asia Minor and Armenia; and when by their weight the waters burst the barrier opposed to them on the side of the Bosphorus, it may easily be conceived with what a fearful shock they must have poured into the Mediterranean. See *Storia Filosofica della Navigazione, del Commercio e delle Colonie degli antichi del Mare Nero*, by Formaleoni, Venet. 1788; also Notes on French Strabo, Paris, 1805.

EVAGRIUS SCHOLASTICUS, an historian, born at Epiphania about the year 536. He practised the profession of advocate, from which he was called *Scholasticus*, a name which was then given to the pleaders at the bar; and he was also tribune and keeper of the prefect's dispatches. He wrote an ecclesiastical history, which begins where those of Socrates and Theodoret ended; besides other works, for which he was rewarded by the emperors Tiberius and Mauricius. M. de Valois published at Paris a good edition of Evagrius's ecclesiastical history in folio; and it was republished at Cambridge in 1620, in folio, by William Reading, with additional notes of various authors.

EVANDER, a king of Arcadia, said to be son, sometimes of Mercury and sometimes of Echemus, king of Arcadia, had as his mother the nymph Nicostrate or Carmenta, according to the Latins. Various reasons are given to account for his emigration to Italy. According to Servius (Virg. *Æn.* viii. 51, 130), he had killed his father by accident; but Ovid says that he was compelled by civil broils to abandon his kingdom to his brother Ladocos. This event is supposed to have taken place about fifty years before the taking of Troy. Faunus, who then reigned in Italy, received Evander and his companions with great kindness, granting to him as much land as was necessary to build a city. Its foundations were laid on the Palatine hill; and it was called Pallatium or Pallanteum, either in honour of his son Pallas, or in remembrance of a village of the same name in Arcadia. Evander was greatly annoyed by the thefts of a giant named Cacus, who dwelt on the Aventine hill; but Hercules, whom he received with much hospitality, freed him from this formidable enemy. At a later period Virgil introduces him to us, as forming an alliance with Æneas, and furnishing him with a body of troops commanded by his son Pallas. (*Æn.* viii. 154). He gave laws to his people, taught the aborigines of Italy agriculture, invented music, and introduced into his new country the knowledge of letters. After his death he was by the gratitude of his subjects ranked among the gods.

EVANGELISTS, the inspired authors of the Gospels. The word is derived from the Greek ευαγγελιον, formed of ευ, *bene*, *well*, and αγγελος, *angel* or *messenger*.

The denomination of *evangelists* was likewise given in the ancient church to those who preached the gospel in different parts, without being attached to any particular church, being either commissioned by the apostles to instruct the nations, or having of their own accord abandoned every worldly attachment, and consecrated themselves to the sacred office of preaching the gospel. In this sense it is, according to some interpreters, that St Philip, who was one of the seven deacons, is called the *evangelist* in the twenty-first chapter of the Acts of the Apostles. Again, St Paul, writing to Timothy (Ep. ii. chap. iv. ver. 5), bids him do the work of an evangelist; whilst the same apostle (Eph. iv. 11) ranks the evangelists after the apostles and prophets.

EVANTES, in *Antiquity*, the priestesses of Bacchus, who were so called because in celebrating the orgia they ran about as if distracted, crying, *Evan, evan, ohe evan.*

EVAPORATION is that process by which liquids and solids gradually assume the gaseous form, or by which, in certain circumstances, an invisible vapour or gas is continually detached from the surface of water, and perhaps of every other liquid, as also from the surfaces of many, if not every solid. From this process being generally found to lower the temperature of the evaporating body, an effect which might have been expected from the doctrine of latent heat, it is probable that heat enters largely into the constitution of every vapour, and is therefore supposed to be the principal agent. At a given temperature, a cubic foot or other determinate space, incumbent over a liquid, cannot contain above a certain quantity of the same kind of vapour; and when it contains that maximum, it is said to be saturated. If, therefore, after this is the case, any additional vapour continue to be thrown off, it must either fall back immediately into the liquid, or, if slightly cooled, may apparently remain suspended in the visible form of a cloud, which, however, is not properly vapour, but minute drops, formed by the cooling of it, and which successively fall back into the liquid. For evaporation continues to go on under the pressure of air or other gas, however dense, but ceases in the presence of any gas, however rare, if already saturated with the same vapour, unless such gas be colder than the evaporating body; in which case, however, the vapour being partly condensed into drops, becomes cloudy, as was just mentioned; and sometimes liquids, while in the act of ebullition, which is rather an extreme case of evaporation, throw up small drops, which may be seen alternately rising and falling in the vapour. Such is a summary of a few of the leading facts, several of which we shall have occasion to touch on more fully, along with other particulars, whilst briefly noticing, as we shall now do, some steps in the history of this inquiry, before proceeding farther.

The spontaneous disappearance of water, and the drying of humid bodies, or the tendency which moisture has to escape from them and diffuse itself in the atmosphere, and afterwards to descend as rain, snow, dew, &c. must have been familiar to mankind in every age, condition, or climate; but any thing like an approach to a rational explanation of the facts seems to be of very modern date. Some of the ancients, particularly Aristotle, conjectured that fire was concerned in the process; but such of their notions as have come down to us are so little to the purpose, that they need not now be dwelt upon. Halley supposed that aqueous vapour consisted of small hollow spherules, filled with something so very light, that they readily ascended and floated in the air,—a theory not altogether such as might have been expected from the known sagacity of its author; for, though Descartes seems to have hinted at the same thing long before, it scarcely appears to have had the least shade of truth in it. But so completely was Kratzenstein's imagination filled with this doctrine, that he fancied he could see these vesicles with a microscope, and even discern them to be hollow, notwithstanding their being supposed to form a transparent vapour. If he really saw any thing, it was more probably minute drops of water descending in the air. Nay, almost up to the close of the last century, we find many eminent men, and among these the late able mathematician Mr George Atwood, maintaining and speculating on this vesicular theory, as it was called. Halley, it is true, hinted at another theory, which not a few embraced, and for which some have still a predilection, namely, that air holds moisture united to it by chemical solution or affinity; but the first idea of this seems to be due to Hooke. A different explanation was attempted by Desaguliers, who, after pointing out the defects of former theories, showed that water is capable of being converted into a transparent elastic fluid, which he supposed to be many times lighter than air, and that it could therefore ascend and float in the atmosphere; but he some time afterwards inclined to ascribe the ascent of vapour to an electrical attraction of the air. Desaguliers was no doubt greatly mistaken regarding the specific gravity of steam, which, under the same pressure and temperature, is now known only to fall short of that of air in the ratio of five to eight; but he was perhaps the first who thought of identifying pure steam with the attenuated aqueous vapour diffused in the atmosphere. It would seem that prior to Desaguliers advancing this notion, it was not known that steam is always generated in a transparent state, although minute drops of water may be passing or falling through it; and indeed some are scarcely aware of this at the present day. The fact is, that steam or aqueous vapour preserves its transparency so long as it has neither lost heat nor had its volume enlarged; but so soon as its temperature is lowered, whether from losing heat or from enlargement of volume, it is more or less condensed into minute drops of water, which of course render it opaque. For we can on no account admit the very generally received doctrine of M. Clement, that equal weights of steam, if in contact with water, contain equal quantities of heat, whatever be their volumes or temperatures. On the contrary, we cannot help believing that a given weight of steam requires more heat to maintain it in the transparent elastic form, when under a greater volume, than under a less; and in proof of this, we presume it is only necessary to adduce the following fact. If we open a stop-cock in the cover of a boiler when the pressure is only one atmosphere, the steam which issues preserves its transparency till it get to some distance from the orifice; but when the pressure within amounts to two or three atmospheres, the steam, if allowed to issue freely, is opaque from the very orifice. This clearly shows that the same quantity of heat (we do not mean temperature) which had been amply sufficient to maintain the steam in the transparent form under a smaller volume within the boiler, is quite inadequate to do so when the steam is allowed to enlarge its volume under a reduced pressure. A more palpable or satisfactory proof than this, which has been long before the public, is scarcely to be wished; yet we find Dr Lardner not long ago reading a paper to the Royal Society on the heat of steam, and which has for its foundation the untenable theory of Clement. Indeed M. Clement's mode of experimenting was so fallacious, that it would have given him the same results whether his theory had been true or not. For when the stream of steam is very small, and of course passes through the stop-cock with difficulty, as it must have done in his experiments, it has, while in the act of dilating from under a force of two or three to that of one atmosphere, the opportunity of absorbing heat from the metal of the scarcely open stop-cock, then much hotter than 212°, the temperature to which the dilating is supposed to reduce the steam. No wonder then that equal weights of steam, at first so different in density, should, when received in equal quantities of cold water, produce equal rises of temperature; as is pointed out more particularly in the *Philosophical Magazine* for July 1826, p. 38. It is likewise to be remembered, that though in the other experiment the steam must have been absorbing some little heat from the stop-cock, this did not enable it to preserve the transparent form. We have been the more particular in clearing up this point, because we shall shortly have occasion to refer to it.

Researches of Saussure.

From the time of Halley and Desaguliers to about 1770, a variety of essays on evaporation made their appearance, which, however, tended but little towards elucidating the subject, because they were either not founded on experiments at all, or on such as were not sufficiently elementary. Some of these sought to establish the vesicular system, while others advocated that of chemical solution and electrical attraction. At length, in 1783, came forth the well known *Essais sur l'Hygrométrie* of M. de Saussure, who, though he did not labour so much to establish new theories as to blend together or combine some of those already mentioned, certainly added considerably to the stock of facts. But he at the same time greatly indulged his fancy in supposing aqueous vapour to be capable of existing in four different forms. When it alone occupied a space, he called it *pure elastic vapour*; when diffused in a transparent state in the air, he named it *dissolved elastic vapour*, imagining it to be chemically dissolved by the air; but after the air was quite saturated with this sort, he thought some of it assumed the form of *vesicular vapour*, only differing from that of Halley in being visible. To these he added *concrete vapour*, which consisted of liquid drops, such as form clouds and fogs; a real form of moisture to be sure, but one which is not properly vapour at all. In these *Essais* we have an account of a variety of experiments, most of them having the advantage of being executed on a great scale; but, on the other hand, they were often deficient in that elementary simplicity which is so important in a research of this nature, if we would avoid sources of fallacy. By inclosing a known weight of caustic alkali in a very large glass balloon, previously filled with thoroughly damp air, Saussure endeavoured to find what quantity of moisture this air contained, from the increase of weight which it communicated to the alkali; and conversely, by weighing a bit of wet linen, and suspending it in the balloon filled with dry air, he estimated how much moisture had evaporated from the linen to render the air thoroughly damp. These two methods not only gave him nearly the same result, but did so whether he used air hydrogen or carbonic acid in the balloon, and even when he employed a mixture of these gases. During these experiments he also observed, by means of a gauge, what change of pressure took place within the balloon from the change of humidity.

By operating at different temperatures, he obtained results from which different conclusions might be drawn to suit different theories; for instance, that the quantity of vapour which could exist in the balloon varied in geometrical progression for equal intervals of temperature, and nearly as the square root of the air's density; and that air of the ordinary density could contain five times as much vapour as a vacuum did; all of which conclusions are now known to be incorrect. Prior to this, Lambert had, from his experiments, drawn a very different but still more erroneous conclusion, that the quantity of moisture varied as the *square* of the air's density.

Theory of Deluc and Dalton.

It was natural to think that the great discordance between the results of these celebrated philosophers should have raised doubts whether they might not both have deceived themselves by too complex a mode of operating, and, therefore, that neither of them was likely to be correct. Accordingly we find M. Deluc, in his *Idées sur la Metéorologie*, hinting at an incomparably more simple theory, which he afterwards developed more fully in the *Philosophical Transactions* for 1792, viz. that the quantity of vapour which can exist in a given space depends upon the temperature alone, and is independent of the presence or density of air, or of any other elastic fluid with which the vapour forms no chemical combination, being the same as if nothing but the vapour occupied that space. In this speculation he also maintained, as Desaguliers had done, that pure steam and the attenuated aqueous vapour diffused in the air are the same. Something similar to this theory was advanced by M. Pictet in his *Essai sur le Feu*, and still more so by Dr Dalton in his *Meteorological Essays*; and it is not improbable that each might have hit upon the same theory before knowing what the others had done. By inclosing his hygrometer along with a little water under a receiver, Deluc found that the indications of that instrument were the same whatever was the density of the included air, or however much he exhausted it; and the same thing held true with other gases. Volta, likewise, from a great variety of experiments, was led to acquiesce in the theory of Deluc.

Dr Dalton's researches.

The theory was farther investigated, in a much more elementary way, by Dr Dalton, as detailed in the *Manchester Memoirs*, vol. v.; but preparatory to noticing it, we shall subjoin his manner of expressing himself on the subject in his *Essays*, p. 201, where, from certain experiments and observations, he infers "that the vapour of water, and probably of most other liquids, exists at all temperatures in the atmosphere, and is capable of bearing any known degree of cold without a total condensation, and that the vapour so existing is one and the same thing as *steam* or vapour of 212° or upwards. The idea, therefore, that vapour cannot exist in the open atmosphere at a lower temperature than 212°, unless chemically combined therewith, I consider as erroneous; it has taken its rise from a supposition that *air* pressing upon vapour condenses the vapour equally with *vapour* pressing upon vapour; a supposition we have no right to assume, and which, I apprehend, will plainly appear to be contradictory to reason and unwarranted by facts; for when a particle of vapour exists between two particles of air, let their equal and opposite pressures upon it be what they may, they cannot bring it nearer to another particle of vapour, without which no condensation can take place, all other circumstances being the same; and it has never been proved that the vapour in a receiver from which the air has been exhausted is precipitated upon the admission of perfectly dry air. Hence, then, we conclude, till the contrary can be proved, that the condensation of vapour exposed to the common air does not in any manner depend upon the pressure of the air." The method which Dr Dalton took to clear up this question is distinguished by an elegant simplicity. In the *first* place, he determined by experiment the expansive force of dry air for each degree of temperature between 32° and 212°; and was the first who did so with any thing like accuracy. He at same time found that 1000 cubic inches of air at 32° expanded to 1376 on being heated to 212°, which comes surprisingly near 1375, the result published by M. Gay Lussac shortly after. But through some inadvertency Dr Lardner (on Heat, p. 57) makes Dr Dalton's result 1325, and then gravely adds, that "the latter (Gay Lussac's) determination has been proved by subsequent experiments to be the more correct." *Secondly*, Dr Dalton ascertained the force of pure steam in contact with water for each degree throughout the same range; and, *thirdly*, he found at what rate dry air expanded, when put in contact with water, and then heated through the various degrees of that range. The result was, that at any particular temperature, the expansive force of dry air in the first case, added to the force of vapour in the second, was exactly equal to their joint expansive force in the third. From this it is obvious that there is either no chemical combination between the air and vapour, or that such combination, if it exist, is quite inert, or goes for nothing so far as this research is concerned. Dr Dalton found, that when other gases were substituted for air, the vapour gave the same results; and similar results were obtained when other vapours were treated as steam. M. Desormes, likewise, by operating in a manner very different from that of Dr Dalton, found the quantity of vapour to be independent of the presence of air or other gases. The question was also examined experimentally by M. Gay Lussac, with his well-known accuracy and ability, and his results precisely agreed with those of Dr Dalton. Still more recently Professor Daniell has made a great variety of interesting experiments on mixtures of gases and vapours, in a manner similar to that employed by Deluc, but with the help of an incomparably better hygrometer; and his researches, too, corroborate the theory completely.

Several objections have been made to this theory; but all of them with which we are acquainted are so nugatory and irrelevant that we do not think they require any refutation. There is, however, a point which the foes as well as the friends of the theory have taken for granted, and which, though extremely probable, it would, for any thing we can see, be very difficult to prove in a direct and unexceptionable manner; viz. that the expenditure of heat in forming a given weight of vapour is the same, whether the process take place in air or other gas, or in a vacuum. Since in most combinations heat is given out, it is a wonder that those who contend for the solution of vapours in gases have not founded some objection on this; for we presume it is the only point on which a doubt could be palmed respecting the theory. It is generally taken for granted too, that the expenditure of heat in forming a given weight of vapour is the same at every temperature; but this assumption we cannot help regarding as very erroneous, because to us it appears quite clear that the expense of heat is greater when the vapour is rarer; and this we maintain for the following reason. The density of steam at 212°, for instance, is about 109 times greater than at 32° Fahrenheit; and we have already seen that steam loses in a considerable degree the elastic form by being dilated to two or three times its bulk; how much more then if dilated 109 times? Hence steam rarefied to such a degree would need a large addition of heat to enable it to maintain the gaseous form; in other words, much more heat must be expended or become latent in forming a given weight of vapour at 32° than at 212°. If steam, when kept separate from water, have its temperature raised by compression at the same rate as air has, it might be shown that the expense of heat in forming vapour at 32° would be to that at 212° as thirteen to eight nearly, that is, in the ratio of the logarithms of the number of times the steam is rarer than water. See *Philosophical Magazine* for April 1832, page 246.

Vapours and gases agree in so many of their properties, that there seems no doubt of their being but one and the same form of matter. Thus, so far as has been examined, every vapour, when kept separate from any sensibly evaporating liquid, expands by heat at the same rate as air and other gases do; and, like gases too, it observes the law of Boyle, by having the force at a given temperature proportional to the density. But since the density of a vapour in contact with its generating liquid increases with the temperature, its force, when so situated, increases much more rapidly than that of air or a mere gas does. However, the precise law which connects the temperature with the density or force seems to be as yet unknown. Dr Dalton having, as already mentioned, ascertained by experiment the force of aqueous vapour between the temperatures of 32° and 212°, deduced from the results what he considered to be the relation between the force and temperature, and for some time it was supposed that by means of it the force could be had for temperatures beyond both limits of that range. Accordingly on this principle he constructed a table which extended from —40°F. up to 325°; and indeed he was pretty fortunate in the extension below 32°, because the half of it has since been so nearly confirmed by the very accurate experiments of M. Gay Lussac, which were carried down almost to —20° *cent.* or —4°F.; but above 212° the supposed law was soon found to give the force too small, and the more so as the temperature is higher. Yet Dr Lardner, in his recent treatise on heat, gives this part of the table expressly as the result of Dalton's "accurate experiments," and not as it really was, a mere extension by means of a formula; nor does he warn us of its erring almost two atmospheres at the upper extremity. It is likewise curious that Dr Lardner, while he notices performances of far less merit, is totally silent respecting the labours of the Committee of the Royal Academy of Sciences at Paris in 1829; though they executed by far the most extensive and accurate experiments that ever were made on steam at high temperatures, as will be found detailed in the *Annales de Chimie* for January 1830. All the English abstracts from this which we have seen are very incorrect. Dr Dalton has more recently published another table of the force of vapour adapted to some of his theoretical views; but from its differing considerably from the results of others, especially those of Gay Lussac, we do not consider it so correct for low temperatures as his first one, part of which is given farther on in this article.

The method employed by M. Gay Lussac to determine experimentally the force of vapour at low temperatures is particularly commendable, and yet its merits seem to have been very much overlooked, even by those who were engaged in similar researches. It may therefore be useful to give a brief account of it here. Other philosophers had either not carried their experiments below 32° at all, or had mismanaged the matter by allowing water to freeze in the tube in such a manner as to obstruct the free motion of the mercury, and likewise to render its altitude ill defined and difficult to be seen. These inconveniences were dexterously avoided by Gay Lussac, who still employed a barometer tube, but one so much longer than ordinary that a considerable part of it next the sealed end was above the mercury, and a portion of this, being bent to about an angle of 60°, was immersed in a cold mixture along with a thermometer. The consequence of this arrangement was, that neither the mercury nor the small portion of water on its top necessarily required to be cooled down at all; because, however moderate their temperature might be, the force of every portion of the included vapour being in equilibrio with the force of that which touched the coldest part of the tube, was just the same as if the whole vapour had been at the temperature of the freezing mixture. A farther advantage was, that after the apparatus had been allowed to remain for a short time in the state now described, the water entirely disappeared from the top of the mercury, having been transferred by evaporation or distillation to the sealed end of the tube, where it was quickly frozen. By this means the mercury became almost as free from moisture as if none had been in the tube. It is, besides, evident that this method could be carried down, not only to and below the freezing point of mercury, but to any temperature, however low, to which the extremity of the tube could be cooled; and that it is applicable to every sort of vapour which does not act upon mercury. In fine, Gay Lussac having placed a barometer tube filled with dry mercury beside and in the same cistern with the one which contained both mercury and moisture, read off the difference in the heights of their mercurial columns with great precision, by means of a microscope which could be shifted up and down a graduated pillar, and the difference was obviously the force of the vapour. Although mercury evaporates at all temperatures, as appears from a bit of gold-leaf becoming white if long suspended over it in a phial, and from the noxious effects of breathing air which has been for some time in contact with a large surface of mercury, yet the force of its vapour is so very small compared with that of steam, that it could not sensibly affect these experiments. Indeed it seems to be a general law, that the forces of vapours from liquids which have high boiling points, are quite inappreciable at low temperatures.

Researches on the rate of evaporation.

The most important problem connected with the evaporation of water is to determine the rate at which, under certain circumstances, it escapes from a given surface at a particular temperature. Many cases of this problem are still very imperfectly solved. The experiments of Dr Halley, detailed in No. 189 of the *Philosophical Transactions*, seem to be among the earliest which were employed for this purpose. He found that water salted to the state of sea water, and exposed to a heat equal to that of a summer's day, did, from a circular surface of eight inches diameter, evaporate at the rate of six ounces in twenty-four hours. Hence he concludes, that a square degree of sixty-nine miles will evaporate 33,000,000 tuns in a day; and supposing the Mediterranean to contain 160 square degrees, it would evaporate 5,280,000,000 tuns daily. This quantity he considers sufficient to supply all the rains, springs, dews, rivers, &c. It would however be of little use to rehearse the whole of this speculation, because the data, as we shall afterwards see, were too loose, and the experiment was on too small a scale, for such a comparison. Dr Lardner, in touching on this subject in his treatise on heat, says, that in the Straits of Gibraltar, instead of an outward current, there is a rapid and never-ceasing inward flow of water, and that he is therefore compelled to conclude that the evaporation from the surface of this sea carries off the enormous quantity of water supplied from this and other sources. Such doctrine from so respectable a quarter rather surprises us; since it is quite well known that, besides the inward current, which is principally in the middle of the surface, there are generally outward currents, likewise at the surface, next the coasts, particularly the south one, and most probably also in the immense deep beneath. According to Professor Robison, the water sometimes flows outward, even in the middle of the surface. Had there been no outward current, the Mediterranean must long ago have become as salt as the brine of the Dead Sea; or rather perhaps have become a rock of salt, as Dr Thomas Young remarked; for, as we shall afterwards see, no common salt or other muriate rises from the sea by evaporation. In

Dr Halley's experiments.

Water carried in by the current at Gibraltar cannot be all spent by evaporation.

order that the same degree of saltness may continue, the outward currents must just bear away as much salt as the inward current and other sources supply, with the very slight exception of what the wind carries off in the form of spray, water spouts, &c. The waters of the Mediterranean being, as is well known, specifically heavier, especially at a great depth, than those of the Atlantic, will naturally incline to buoy them up, and flow out beneath them in the infathomable depth of the Straits.

Dr Dobson's experiments.

A series of experiments on the evaporation of water at natural temperatures was continued for four years, beginning with 1772, by Dr Dobson, at Liverpool, as detailed in the *Philosophical Transactions*, vol. lxvii. He took a cylindrical vessel twelve inches in diameter, and having nearly filled it with water, exposed it beside his rain-gauge of the same aperture; and by adding or withdrawing water, as occasion required, he kept the surface at nearly the same height. By comparing the total quantities thus added or taken away with the proceeds of the rain-gauge, the amount of evaporation was ascertained. The mean monthly evaporation for the four years was, in January, 1·5 inches; February, 1·77; March, 2·64; April, 3·3; May, 4·34; June, 4·41; July, 5·11; August, 5·01; September, 3·18; October, 2·51; November, 1·51; December, 1·49. In all, 36·78 inches. The mean rain for the same time was 37·48. For a great deal more in this way, and on the evaporation of ice and snow, see Howard's excellent treatise on *The Climate of London*. That ice and snow evaporate, appears from their losing weight, or even disappearing altogether, if long enough exposed to a brisk and dry wind during frost. But sometimes snow is rendered so much colder by radiation than the incumbent still air, that it condenses the vapour of that air into hoar-frost, and by that means augments its own weight or bulk.

But the experiments of Dr Dalton and Mr Hoyle, though rather of local application, were no doubt far more accurate for evaporation from the soil. Having got a cylindrical vessel three feet deep and ten inches in diameter, two pipes were joined to it, and turned downwards for the surplus rain-water to run off into bottles; the one pipe being near the bottom, the other an inch from the top. The vessel was filled up for a few inches with gravel and sand, and the remainder with good fresh soil. It was then put into a hole in the ground, and the space around filled up with earth, except on one side, for the convenience of afterwards joining bottles to the pipes, and registering their contents. The earth in the vessel was now saturated with moisture, by pouring in water till some of it escaped from the pipes; and, lastly, the bottles were put to. During the first year the soil was bare at top; but for the next two years it was covered with grass, like any green field. A regular register was kept of the rain-water which ran off through the upper pipe, and also of what sunk down through the earth to the lower pipe. A rain-gauge of the same diameter was kept close by, to register the quantity of rain for any corresponding time.

	Water through the two Pipes.			Mean.	Mean Rains.	Mean Evaporation from Ground.	Mean Evaporation from Water.
	1796.	1797.	1798.				
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
January..........	1·897	0·680	1·774	1·450	2·458	1·008	1·5
February..........	1·778	0·918	1·122	1·273	1·801	0·528	2·
March..........	0·431	0·070	0·335	0·279	0·902	0·623	3·5
April..........	0·220	0·295	0·180	0·232	1·717	1·485	4·5
May..........	2·027	2·443	0·010	1·493	4·177	2·684	4·959
June..........	0·171	0·726	...	0·299	2·483	2·184	6·487
July..........	0·153	0·025	...	0·059	4·154	4·095	5·628
August..........	...	...	0·504	0·168	3·554	3·386	6·058
September..........	...	0 976	...	0·325	3·279	2·954	3·898
October..........	...	0·680	...	0·227	2·899	2·672	2·351
November..........	...	1·044	1·594	0·879	2·934	2·055	2·042
December..........	0·200	3·077	1·878	1·718	3·202	1·484	1·5
	6·877	10·934	7·379	8·402	33·560	25·158	44·4
Rain......	30·629	38·791	31·259				
Evap......	23·725	27·857	23·862				

From these experiments it appears, 1*st*, That the mean annual quantity of water evaporated in the above circumstances is twenty-five inches of rain, to which if we add five for dew, will give thirty inches of water raised annually: 2*dly*, That the evaporation increases nearly, though not exactly, in the same ratio as the rain; thus 1797 gave most rain, and the greatest evaporation, &c.: 3*dly*, That there is little difference between the evaporation from bare earth of sufficient depth, and that from ground covered with grass. It is however to be observed, that the numbers in the last or right hand column belong to the years 1799, 1800, and 1801; and that on account of accidents with the frost, these numbers are partly conjectural for January, February, March, April, and December. The mean annual evaporation during the same three years from ground covered with grass, exclusive of dew, was 23·5 inches, which falls a little short of that for the other three, which was twenty-five.

But there is reason to suspect that a less depth of soil in the vessel would have allowed more water to escape into the bottles, and *vice versa*. It is therefore in some degree a matter of conjecture that this apparatus indicated the true evaporation from the adjacent fields. Lahire having filled a vessel eight feet deep with soil, and sunk it into the earth, left it there for fifteen years. It had an opening at the bottom for the escape of the water, but never a drop came through. The quantity of rain, to be sure, being less at Paris than at Manchester, will so far account for this.

In such an article as this it might be expected that, in conformity with custom, we should state the mean evaporation for all England, and a number of other principal countries. This however we are unable to do, because we are persuaded that to obtain even an approximate estimate would require experiments, such as those of Dr Dalton from the soil, to be made at least within every square mile of surface. The usual estimates being only derived from a vessel with water, as will be noticed more particularly afterwards, afford no measure of evaporation from the soil.

The following relation between the temperature and the rate of evaporation from water, was discovered by Dr Dalton. Having, as above mentioned, determined experimentally the force through a considerable range, he was naturally led to examine whether the quantity of water evaporated in a given time bore any proportion to the force of vapour of the same temperature, and was agreeably surprised to find that they corresponded in every part of the range examined. Thus the forces of vapour at 212°, 180°, 164°, 152°, 144°, and 138°, are equal to 30, 15, 10, 7·5, 6, and 5 inches of mercury respectively; and the grains of water evaporated per minute are in the same ratio. This Dr Dalton considers as quite in conformity with the laws of mechanics; for the atmosphere seems by its inertia to obstruct the diffusion of vapour, which would otherwise be almost instantaneous, as in vacuo; but this obstruction, which is greater as the air is more dense, is overcome in proportion to the force of the vapour. Did the obstruction arise from the weight of the atmosphere, it would prevent any vapour from rising at temperatures lower than 212°; but according to Dr Dalton it is caused by the inertiæ of the particles of air, and is similar to that which water meets with in descending among pebbles.

The theory of evaporation was thus far settled so much the more easily, because the force of vapour already in the open air being very small compared with what is produced from water at high temperatures, did not sensibly affect the results; but Dr Dalton found, that if the theory was to be verified by experiments for low temperatures, regard must be had to the force of vapour already in the atmosphere. For instance, if water of 59° were the subject, the force of vapour at that temperature being a sixtieth of the force at 212°, one might expect the quantity of evaporation to be a sixtieth also; but if it should happen, as it sometimes does in summer, that an aqueous atmosphere to that amount does already exist, the evaporation, in place of a sixtieth, would be nothing at all. On the other hand, if the previously existing vapour were the 120th, corresponding to 39° F., then the effective evaporating force would be the 120th of that from boiling water. In short, Dr Dalton found that the evaporating force must in every case be equal to that at the temperature of the water diminished by that already existing in the air. To find the force of the aqueous atmosphere, Dr Dalton revived the method which had been employed by Leroy long before. He used in summer to take a tall glass jar, and fill it with cold spring water, fresh from the well. If dew was immediately formed on the previously dry outside, he poured the water out, let it stand a little to rise in temperature, wiped dry the outside of the jar, and then poured the water in again. The like process is to be repeated till dew cease to be formed, and at that instant the temperature of the water is to be carefully noted, for the purpose of obtaining, from a table like that which shortly follows, the corresponding force of vapour. Such temperature is called the *dew point*, or the *point of deposition*; because the air, if cooled to it, would be in a state of saturation with moisture, and of course ready to deposit dew, especially on any thing in the least colder than itself. This operation should be performed in the open air, or at an open window, because the air within is generally more humid than without. Spring water in this country being generally within a degree or two of 50°, will mostly answer the purpose during the three hottest months; in other seasons an artificial cold mixture may be used. But Leslie's or Daniell's hygrometer would be still more convenient at all seasons.

To observe the evaporation at atmospheric temperatures, Dr Dalton had two light tin vessels; the one six inches diameter and half an inch deep, the other eight inches diameter and three fourths of an inch deep, and both made to be suspended from a balance. Water being put in one of these and weighed, it was placed in an open window or other exposed situation for ten or fifteen minutes, and again weighed to ascertain the loss from evaporation. The temperature of the water was at same time observed, the force of the aqueous atmosphere ascertained as above, and the velocity of the current of air noticed; for with the same evaporating force, a strong wind, by quickly changing the air in contact with the water, will double the effect produced in still air. From a great variety of experiments made during both winter and summer, and when the evaporating force was strong and weak, even in the case of ice, the results were found perfectly conformable with the theory. The same quantity is evaporated with the same evaporating force thus determined as near as can be judged, whatever be the temperature of the air. Thus, if the dew point be 40° while the air is at 60°, the evaporation is the same as if the dew point were at 60° and the air at 72°; for ·524 — ·263, which is the difference of the forces of vapour at 60° and 40°, is nearly equal to ·770 — ·524, the difference of the forces at 72° and 60°; but two such differences could be had exactly equal by using fractions of degrees of temperature, and interpolating between the other numbers.

The following table exhibits the ratios and quantity of water evaporated at different temperatures, derived from the preceding theory, and confirmed by experiments. The first column is the temperature; the second the force of vapour; the rest give the number of grains evaporated from a surface six inches in diameter, supposing the air to be previously dry. The third column is calculated on the supposition that at the temperature of 212° the evaporation per minute from the said surface is 120 grains; the fourth, that it is 154 grains; the fifth, 189, according to the strength of the wind; for if the air in contact with the water be continually changed, so that the recently moistened portion may be speedily removed and drier air substituted for it, the process will be proportionably expedited. These columns present the extremes and mean of evaporation likely to be noticed when the process goes on in air of the ordinary density. The effects of different densities will be considered afterwards.

Table of the Force of Evaporation.

Temperature.	Force, Inch.	Evaporating Force in Grains.		
20°	·129	·52	·67	·82
21	·134	·54	·69	·85
22	·139	·56	·71	·88
23	·144	·58	·73	·91
24	·150	·60	·77	·94
25	·156	·62	·79	·97
26	·162	.65	·82	1·02
27	·168	·67	·86	1·05
28	·174	·70	·90	1·10
29	·180	·72	·93	1·13
30	·186	·74	·95	1·17
31	·193	·77	·99	1·21
32	·200	·80	1·03	1·26
33	·207	·83	1·07	1·30
34	·214	·86	1·11	1·35
35	·221	·90	1·14	1·39
36	·229	·92	1·18	1·45
37	·237	·95	1·22	1·49
38	·245	·98	1·26	1·54
39	·254	1·02	1·31	1·60

Table of the Force of Evaporation continued.

Temperature.	Force, Inch.	Evaporating Force in Grains.		
40	·263	1·05	1·35	1·65
41	·273	1·09	1·40	1·71
42	·283	1·13	1·45	1·78
43	·294	1·18	1·51	1·85
44	·305	1·22	1·57	1·92
45	·316	1·26	1·62	1·99
46	·327	1·31	1·68	2·06
47	·339	1·36	1·75	2·13
48	·351	1·40	1·80	2·20
49	·363	1·45	1·86	2·28
50	·375	1·50	1·92	2·36
51	·388	1·55	1·99	2·44
52	·401	1·60	2·06	2·51
53	·415	1·66	2·13	2·61
54	·429	1·71	2·20	2·69
55	·443	1·77	2·28	2·78
56	·458	1·83	2·35	2·88
57	·474	1·90	2·43	2·98
58	·490	1·96	2·52	3·08
59	·507	2·03	2·61	3·19
60	·524	2·10	2·70	3·30
61	·542	2·17	2·79	3·41
62	·560	2·24	2·88	3·52
63	·578	2·31	2·97	3·63
64	·597	2·39	3·07	3·76
65	·616	2·46	3·16	3·87
66	·635	2·54	3·27	3·99
67	·655	2·62	3·37	4·12
68	·676	2·70	3·47	4·24
69	·698	2·79	3·59	4·38
70	·721	2·88	3·70	4·53
71	·745	2·98	3·83	4·68
72	·770	3·08	3·96	4·84
73	·796	3·18	4·09	5·00
74	·823	3·29	4·23	5·17
75	·851	3·40	4·37	5·34
76	·880	3·52	4·52	5·53
77	·910	3·65	4·68	5·72
78	·940	3·76	4·83	5·91
79	·971	3·88	4·99	6·10
80	1·00	4·00	5·14	6·29
81	1·04	4·16	5·35	6·54
82	1·07	4·28	5·50	6·73
83	1·10	4·40	5·66	6·91
84	1·14	4·56	5·86	7·17
85	1·17	4·68	6·07	7·46
212°	30	120	154	189

As an example of the use of the table, let the dew-point be 52°, the temperature of the air 65°, with a moderate breeze, to find the evaporation per minute from a vessel six inches in diameter. The number in the fourth column opposite 52° in the first, is 2·06, and that opposite 65° is 3·16; the difference, 1·1 grain, is the evaporation required. Again, if the evaporation per minute, with a brisk wind, be 1·7 grain, while the air is at 62°; required the weight of the aqueous atmosphere, and the dew-point. In the fifth column the number opposite 62° is 3·52, being the whole evaporating force at that temperature in perfectly dry air, from which 1·7 being deducted, leaves 1·82, which, in the fifth column, is opposite to ·294 inch of mercury in the second, the weight of the column of vapour, and to 43° the temperature or dew-point. That is by using the nearest numbers in the table. Greater exactness may be had by interpolating between them. In this case, for instance, the weight should more correctly be ·290, and the dew-point 42°·6. Such estimates, however, are liable to uncertainty, where any doubt remains respecting the velocity of the wind.

Dr Dalton found that the same theory held with regard to the evaporation of other liquids, and was even more easily verified by experiment in their case than in that of water, on account of the air previously containing little or none of their vapours. In short, the evaporation in their case is similar to that of water in perfectly dry air.

Since vapours, so long as they maintain the gaseous form, expand and contract by change of temperature precisely at the same rate as air does in like circumstances, and since mixtures of air and vapour do the same, it follows, that if at any temperature above the dew-point the pressure of the unconfined air have to that of the vapour in it a certain ratio, it will have the same ratio to it at any other temperature not lower than the dew-point. Hence, because the entire pressure is constant, the force of vapour at the actual temperature of the air is exactly equal its force at the dew-point or temperature at which the air under the original pressure becomes saturated with moisture, and at which all the moisture in it just barely maintains the gaseous form.

Dr Anderson, in giving a table of the weight and force of aqueous vapour *in vacuo* (*Edin. Encyc.* xi. 578), says, it is adapted to a pressure of thirty inches, and that when the barometer differs from thirty, the numbers in the table (none of which denote atmospheres, but grains and inches) must be altered in the same ratio as the pressure. It is difficult to conceive how he could fall into such a palpable mistake. Vapour *in vacuo* being protected from atmospheric pressure, has obviously nothing to do with its changes or amount; and we have already seen that the maximum force and density of vapour in air, as well as *in vacuo*, depend solely on the temperature. Yet Dr Anderson (*ibid.* p. 581) makes the maximum weight of vapour which can exist in a cubic inch of air at a given temperature to be proportional to the barometric pressure, which is remarkable, considering his professed adherence to Dalton's theory. It is farther curious that the doctor, not perceiving that the actual force of vapour in the open air must be exactly equal to its force at the dew-point, gives (on same page) a formula for reducing the one force to the other; and he even takes it for granted that Dr Dalton is in the same error, though the very reverse appears from all his writings, and especially those already quoted.

The rate of evaporation is very different in air of different densities, being greater when the density is less, and *vice versa.* Some experiments on this subject are given by Professor Daniell, in the second and much improved edition of his valuable *Meteorological Essays*, published in 1827, page 493, from which we make the following brief abstract:—Upon the plate of an air pump was placed a flat dish 7·5 inches diameter, containing sulphuric acid, and covered by a receiver which but just passed over it, so that the base of the included air rested everywhere on the acid. In the middle of the dish was a stand supporting a vessel 2·7 inches diameter, and 1·3 deep, which was filled with water to the depth of an inch, and had a delicate thermometer resting on its bottom. The water, having been previously freed from air, was weighed with a very sensible balance, and then exposed to the action of the sulphuric acid. Its temperature was 45°, and the barometer at 30·4 inches. At the end of half an hour it was again weighed, and found to have lost 1·24 grain by evaporation. Having been replaced, and the air rarefied till the gauge stood at 15·2 inches, it was found to have lost in half an hour 2·72 grains, and to have had its temperature reduced to 43°. By repeating the process, continually diminishing the pressure one half, the successive losses from evaporation in intervals of half an hour each, were as follow:—

Pressure.	Temperature. Beginning.	Temperature. End.	Loss, Grains.
30·4	45°	45°	1·24
15·2	45	43	2·87
7·6	45	43	5·49
3·8	45	43	8·80
1·9	45	41	14·80
·95	45	37	24·16
·47	45	31	39·40

When the exhaustion was pushed to the utmost, which was ·07 inch, the evaporation in the half hour was 87·22 grains. During this last experiment the water was frozen in about 8 minutes, while the thermometer under the ice was at 37°. There must, however, be some inadvertency respecting the loss from evaporation in the second experiment; because in the table it is 2·87, and in the account before it only 2·72, which last, we presume, is the more correct of the two.

Before inferring from these experiments the rate of evaporation under different pressures, Mr Daniell applied to the results a correction for the variation of temperature. Taking the evaporation as proportional to the elasticity of the vapour, he estimated the latter from the mean of the temperatures at the beginning and end of each experiment, and calculated the amount for a fixed temperature. This might have been supposed to give a near approximation, were it not evident from the last experiment, that, owing to the bulb of the thermometer not being close at the evaporating surface, it indicated often too high a temperature; but the following table presents the results computed on that principle for the temperature of 45°; and here again we suspect the second number 2·97, being computed from 2·87, is too great.

Pressure.	Grains.
30·4	1·24
15·2	2·97
7·6	5·68
3·8	9·12
1·9	15·92
·95	29·33
·47	50·74
·07	112·32

Notwithstanding the slight irregularity of the series, Mr Daniell thinks we can run no risk in concluding that the amount of evaporation is, *cæteris paribus*, in exact inverse proportion to the elasticity of the incumbent air. But perhaps it would be more correct to say, that, *cæteris paribus*, the rate of evaporation is inversely as the *density* of the air; for that is Dr Dalton's view of the matter, and is equally conformable to these experiments. It may however be observed, that the rate of evaporation in the first case, which is in air of the ordinary density, is much smaller than that given by Dr Dalton; but the process going on in so small a volume of still and confined air, seems a sufficient reason for this.

Coolin influen of evap ration.

It was hinted above, that evaporation tends to lower the temperature of an evaporating surface, by abstracting heat from it for the formation of vapour. For, from the well known fact, that in the formation of aqueous vapour as much heat is absorbed as would raise the temperature of 1000 times its weight of water one degree, it follows, that were it not for the heat derived from surrounding bodies, the vaporization of the 1000th part of a mass of water would lower the temperature of the whole one degree; so that, by the time the 100th part had evaporated, the temperature of the whole would have fallen ten degrees. But surrounding bodies, particularly the air, by participating in the cooling effects, supply heat in such a manner to the water, that a limit is soon set to the fall of temperature. Although this cooling influence has been long known in a general way, it is remarkable how few experiments have been made, or, so far as we know, published, to show the extent of cold produced in different circumstances; and still more remarkable, that those few results of different experimenters should differ so widely, as we shall presently see they do. Dr Anderson, in the article *Hygrometry*, in the *Edinburgh Encyclopædia*, gives the following as the results of his experiments on the cold produced by the evaporation of water in air of different densities. For this purpose he placed Leslie's hygrometer, along with a cup of sulphuric acid, under a receiver of the air pump.

Dr Anderson's experiments.

29·6	48°·5	43°·64	4°·86	27°
23·6	48 ·5	42 ·38	6 ·12	34
17·6	48 ·5	40 ·58	7 ·92	44
11·6	48 ·5	37 ·34	11 ·16	62
5·6	48 ·5	32 ·12	16 ·38	91

The first column is the pressure in inches, the second the Fahrenheit temperature of the dry bulb, the third that of the moist, the fourth their difference or the depression, and the fifth the same depression in degrees of Leslie's hygrometer. The third and fourth columns, though not in the original, are obviously obtained from the others, and inserted in degrees of Fahrenheit, for the sake of comparison with those which follow.

In an article on hygrometers and evaporation, in the *Edinburgh Philosophical Journal* for October 1826, Mr Meikle gives the two following series of similar experiments, which were not made with Leslie's hygrometer, but with what was reckoned preferable for the purpose, two common thermometer tubes fitted upon one broad and doubly graduated scale; the one bulb being dry and the other covered with wet linen. The columns respectively denote the same things as the first four in Dr Anderson's.

Mr Meikle's experiments.

29·7	48°·2	36°·6	11°·6
19·4	47 ·3	33 ·2	14 ·1
17·2	47 ·2	32 ·5	14 ·7
13·3	47 ·0	31 ·2	15 ·8
8·8	46 ·4	27 ·2	19 ·2
29·9	60°·6	45°·5	15°·1
20·0	59 ·5	41 ·0	18 ·5
10·0	58 ·9	34 ·1	24 ·8
5·6	58 ·5	28 ·0	30 ·5

All sealed thermometers stand too low when the pressure of the atmosphere is removed from their bulbs. The two just mentioned were found to be each 1°·5 too low in an exhausted receiver. Hence most of the numbers in the second and third columns still require to be more or less corrected for this, according to the degree of exhaustion; but since both thermometers were equally affected, the depressions have nothing to do with it. However, the included air seems to have been really a little cooled from the influence of the cold wet bulb.

We have always been puzzled to account for the extreme smallness of Dr Anderson's depressions in the fourth column. Perhaps he had used very weak sulphuric acid, or too small a surface of it; or he might not be aware that the full effect in a single case is seldom attained in less than half an hour. The pressure and temperature in his first case are nearly the same as in Mr Meikle's; and yet the depression 4°·86 is not half of 11°·6. From many trials we know that the weather is by no means very droughty, if a wet thermometer do not fall more than 4°·86, when only exposed in the open air at 48°·5, without any sulphuric acid at all. To increase the cold in a wet thermometer, Dr Lardner recommends exposing it to the sun. But whoever takes the trouble of properly trying this, will find that the sun has quite the contrary effect; and therefore the doctor is just in the same delusion, only on a greater scale, when he directs his readers to wrap wine bottles in wet cloth, and expose them to the sun as a source of greater cold! The sun, like the fire, aids evaporation, by supplying heat, which will more or less counteract the cooling effect, and may even raise the temperature; but common sense revolts at the very idea of the heating rays of the sun being a source of cold.

In 1827, Professor Daniell published, in the second edition of his *Essays*, p. 499, a series of experiments on the cooling effects of evaporation, and which, like Mr Meikle's, were made by means of two common thermometers, the one dry and the other moist; but he seems only to have read off to the nearest half degree; and his depressions, though not so deficient as those of Dr Anderson, still lean considerably to the same side. The following are his results, arranged as the preceding:

Mr Daniell's experiments.

30·2	50°	41°	9°
15·1	49	37	12
7·5	49	34	15
3·7	49·5	31·5	18
1·8	49·5	28·5	21
.9	49	24·5	24·5
·4	49	23	26

From repeated experiments we have found that at the temperature of 50°, and under a pressure of about thirty inches, a wet thermometer, when inclosed in a receiver along with a sufficiently large surface of strong sulphuric acid, should fall 12°·1 or 12°·2, in place of 9°, as Mr Daniell has it. The rest of his depressions are still more deficient; but when we attend to the disposition of his apparatus, our surprise rather is that the depressions should be so great as they are. What we particularly object to is his not only inclosing a vessel with water under the receiver, but interposing it directly between the wet bulb and the sulphuric acid. This he did for the purpose of occasionally dipping that bulb in the water; a precaution which was not only unnecessary, but which, by rendering the air moist and obstructing the drying of the bulb, must obviously have rendered the whole of his depressions much smaller than they should have been in perfectly dry air. When Mr Meikle made his experiments, and they were published before those of Mr Daniell, he satisfied himself that if the thermometer was properly covered and moistened at first, no renewal of moisture was necessary. This he ascertained by repeating, in a retrograde order, the different cases when he had just completed a series of these experiments; for on finishing with the case in which the air was most rarefied, he readmitted as much air as just brought back the gauge to the next case, which being repeated, he readmitted more air for the next, and so on, till he had got back over the whole series. In every case, the wet thermometer was found to be as much depressed in the backward process as in the forward, a clear proof that there was no lack of moisture. Neither Dr Anderson nor Professor Daniell say whether they made any allowance for the effects of pressure on the bulbs of their thermometers.

Cold not yet observed in vaporizing turpentine.

Oil of turpentine is well known to evaporate very quickly, but we have as yet failed to detect any cold that it produces, though we do not therefore suppose it forms any exception to the general law. Some liquids, as alcohol, ether, sulphuret of carbon, &c. both evaporate more rapidly than water does, and produce a greater cold; but the expenditure of heat is greater in vaporizing a given weight of water than of any other liquid yet examined; a fact from which it had often been concluded that alcohol could be vaporized with so much less fuel than water, that its vapour would be an economical substitute for steam as a first mover; nay, this had become a standard doctrine in almost every scientific compilation. It however involved a fatal oversight, as was first pointed out by Mr Meikle in the *Philosophical Magazine* for July 1826, p. 41, and afterwards by Mr Ainger in Brande's *Journal of Science* for March 1830; for it is not with equal *weights*, but with equal *volumes* of these vapours, that the comparison falls to be made; and when this is done, the greater rarity of steam puts it on at least an equal footing with alcoholic vapour, so far as regards the economy of heat. In other respects, steam is decidedly preferable; for, independently of the enormous expense of alcohol, the density of its vapour, being about 2·5 times that of steam, would prevent it from moving with the same facility through the pipes, valves, &c.

Perhaps it may not be altogether foreign to our subject to mention, that Mr Hutton froze alcohol by condensing air on it in a strong vessel, which being very much cooled by freezing mixtures, was next suddenly opened, when the dilatation of the air, and the consequently rapid evaporation and re-expansion of the alcohol, absorbed so much heat as induced a cold sufficient to freeze it.

The bad effects of damp clothes, beds, &c. are usually ascribed to the cold attending the evaporation of the damp; but since considerable injury often follows where scarcely any cold is felt, we suspect the chief cause lies rather in the moisture suppressing the natural evaporation from the skin. The heavy smell which accompanies most dogs, and the fetid grease upon their hair, show that they perspire in some other shape besides what some suppose the only one from their tongues.

Various instruments have been employed to measure the rate at which moisture escapes into the atmosphere. We have already alluded to the method of exposing water in a vessel, and noting the loss. The vessel is generally circular, with a roof a little above it to keep off the rain, &c.; and, for greater accuracy, the contents may either be weighed from time to time, or measured in a graduated tube. When the vessel is brim full, the wind is apt to blow some of the water over; and when not full, the water is in some measure sheltered from the drying effects of the wind. The only use of such an instrument or gauge is to give us a very vague idea of the drying power of the air. It affords no measure whatever of the evaporation from the ground; for when the soil is exceedingly parched, and consequently has next to no moisture to give off, the gauge generally shows the greatest evaporation of all. Yet in stating the particulars of the climate of a place, it is usual to mention the amount of evaporation derived most probably from no better source. But it cannot even be a measure of the evaporation from a lake, because in that case the indications of the gauge depend very much on the direction of the wind; for it is obvious that if a previously dry wind traverse an extensive lake before reaching the gauge, it may by that time have become so humid as to show little or no drying power at all upon the gauge. When, on the other hand, the wind passes first over the gauge, its indications are to be suspected of erring in excess, because the farther a wind continues to traverse the surface of a lake, the more will its drying power be impaired, and therefore the average rate of evaporation will be less than at the side next the gauge. For this reason the evaporation from a smaller surface of water is, *cæteris paribus*, greater in proportion to the area than from a larger. Whether any general rule could readily apply to this, we are unable to say. Perhaps something like an approximation to the relation between the area and evaporation in such circumstances would be had by dividing the area by some root of its mean linear dimension taken in the direction of the wind, and multiplying by a constant. But this would not in the least rectify the indications of the gauge. Since similar objections must obviously attach to all gauges employed for this purpose, it would be of little use to give any farther account of them, or of the registers of evaporation with which many works otherwise valuable are so often encumbered.

No uria-
tic d in
sea r.

It had been long supposed that muriatic acid vapour existed in the atmosphere incumbent over the ocean or on the sea coasts; and various effects were ascribed to its presence. But from experiments detailed in the *Journal de Pharmacie* for November 1833, it appears that such effects are solely owing to minute drops of salt water or spray which have been swept into the atmosphere by the wind; and that, with the exception of the salt drops thus raised, though only when the sea is ruffled by the wind, sea-air contains neither muriates nor uncombined muriatic acid. At first sight we had some doubt whether this would account for the injurious effects of sea-air on vegetation; because the presence of common salt, if not in excess, is known to be beneficial. But perhaps the salt when united with the soil may operate as a cordial to the roots, while it may be noxious when in immediate contact with the stem or leaves, as is often the case with manure injudiciously applied close to the roots of plants.

Co la-
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In the method of forming ice in India by exposing water during the night to the aspect of a clear sky, the effect was for some time ascribed to evaporation; but Dr Wells ascertained that the water thus exposed gained in place of losing weight. Now it could only gain by being cooled below the dew point of the incumbent air; for it is only in that state that the air could yield a portion of its moisture to the water; and therefore the cold must be the effect of radiation, and not of evaporation. This was farther evident from the circumstance that wind which ought to have increased the evaporation prevented the freezing altogether. But independently of these considerations, water exposed in the open air could never be cooled to the freezing point by evaporation alone in a hot climate. Where such a thing occurs, the air must be unusually dry, even after its temperature scarcely amounts to 40°, or the atmospheric pressure must be very small; because the utmost evaporation that can be produced artificially under the ordinary pressure will little more than cool a wet thermometer from 40° to 32°; and the cooling effect on a vessel with water is not nearly so great, especially in the open air, if care be taken to avoid the influence of radiation under the aspect of a clear sky. It is true that, at Benares for instance, the surface of the ground, after becoming very cold by radiation, sometimes renders the incumbent still air also pretty cold; but this, by bringing the air to a state of saturation with moisture, totally unfits it for aiding the freezing by evaporation.

So great is the difference of opinion respecting the influence of electricity on evaporation, that we suspect it has not yet been sufficiently investigated. The use of evaporation in the arts and manufactures will be found under the respective articles. In addition to the various works noticed in this article, see Dr Thomas Young's *Natural Philosophy;* Wells *on Dew;* Pouillet's *Elemens de Physique et de Météorologie.* A variety of articles on this subject will be found in the different volumes of the *Philosophical Transactions*, and other scientific journals. (E. E. E.)

EVATES, a branch or division of the Druids, or ancient Celtic philosophers. Strabo divides the British and Gaelic philosophers into three sects; Bards, Evates, and Druids. He adds that the Bards were the poets and musicians, the Evates the priests and naturalists, and the Druids were moralists as well as naturalists. But Marcellus and Hornius mention only two sects, the Bards and Druids.

EVE, the mother of all mankind, who, being deluded by the serpent, occasioned the fall, with all its consequences.

EVELYN, John, a distinguished naturalist and writer on various subjects, was born at Wotton in Surrey, on the 31st of October 1620. In the fifth year of his age he was sent to Lewes in Sussex, where he was placed under the superintendence of his grandfather. The latter, however, having died in 1627, Evelyn in the following year was sent to learn his "Latin rudiments, and to write." In 1637, he entered as a student in Baliol College, Oxford; and in 1640 he removed to the Middle Temple, London. But his studies were interrupted by the civil commotions of this period; and about a year after his arrival in the Temple, he left England for the Continent. He returned in 1642; but the rupture between the king and the parliament had now assumed a serious aspect; loyalty could no longer be professed with safety; and in the year following, having asked and obtained the king's leave of absence, he became an exile, and spent several years in travelling through France and Italy. His powers of observation appear to have been great; and the curious and useful information which he thereby acquired constitutes the charm of many of his works, particularly of his diary. In 1647 he married the only daughter of Sir Richard Browne, the king's minister at Paris, in whose right he acquired the mansion of Sayes Court, near Deptford. This matrimonial alliance was a happy one. In his wife he possessed a woman of an enlightened mind, and of dispositions congenial with his own. That Evelyn must have conducted himself with more than ordinary prudence and discretion, appears evident; for whilst he thus allied himself with Sir Richard Browne, the ambassador of King Charles II. at Paris, he possessed several personal friends at the court of Cromwell, and in fact returned to England a few months after his marriage. Here he remained till 1649, when he again departed for the Continent; but returned to England in 1651. His manners, we may presume, were very agreeable, for his company was sought by the most eminent foreigners; and during his travels he made acquaintance not only with individuals distinguished for their learning, but with ingenious men belonging to every art and profession.

After his final settlement in his native country, Evelyn engaged in literary pursuits. His first undertaking was a translation from the French; and from the period of its publication to the close of a long life, he continued to give to the world original works replete with information alike useful, entertaining, and philosophical. These will be afterwards enumerated. After the death of Cromwell he interested himself in the restoration of Charles II., for which he was much favoured by that monarch, after his resumption of the royal prerogative. In 1660–61 he was nominated by his majesty one of the council, and chosen by the rest of the members a Fellow of the Philosophical Society, which met at Gresham College. This institution formed the basis of the Royal Society, which was established about two years afterwards, and to which Evelyn read a treatise on forest trees. This discourse formed the foundation of his most celebrated production entitled *Sylva.* In 1664 Evelyn was appointed one of the commissioners of the sick and wounded, and likewise a commissioner for rebuilding St Paul's Cathedral. When the board of trade was established by Charles II. Evelyn was nominated one of the members; and on this occasion he drew up a tract on navigation and commerce. In the reign of James II. he was one of the commissioners for executing the office of privy seal during the absence of the Earl of Clarendon in Ireland. He continued in favour at court even after the revolution, and was made treasurer of Greenwich Hospital, the foundation stone of which he laid in the year 1696. By the death of his elder brother in 1699, he succeeded to the paternal estate, and quitted Sayes Court for Wotton, where he passed the remainder of his life, excepting occasional visits to London, where he died on the 27th of February 1705–6, in the eighty-sixth year of his age.

In his personal character Evelyn was truly amiable. He discharged the relative duties of father, husband, and friend, in an exemplary manner; and during his long and useful, rather than splendid career, numerous offices of trust were reposed in him; nor was this confidence misplaced. His correspondence with foreigners as well as Englishmen was so extensive, that it is surprising he should have found time for examining what was deemed worthy of curiosity or of scientific observation, and for composing the great variety of works which he published. "His life," says Horace Walpole, "was a course of inquiry, study, curiosity, instruction, and benevolence. The works of the Creator, and the minute labours of the creature, were all objects of his pursuit. He unfolded the perfection of the one, and assisted the imperfection of the other. He adored from examination, was a courtier that flattered only by informing his prince, and by pointing out what was worthy for him to countenance; and really was the neighbour of the gospel, for there was no man that might not have been the better for him. Whoever peruses a list of his works will subscribe to my assertion. He was one of the first promoters of the Royal Society, a patron of the ingenious and the indigent, and peculiarly serviceable to the lettered world; for, besides his writings and discoveries, he obtained the Arundelian library for the Royal Society. Nor is it the least part of his praise that he who proposed to Mr Boyle the erection of a philosophical college for retired and speculative persons, had the honesty to write in defence of active life against Sir George Mackenzie's *Essay on Solitude.* He knew that retirement, in his own hands, was industry and benefit to mankind, but in those of others, laziness and inutility." The principal works of Mr Evelyn are, 1. An Essay on the First Book of Lucretius, in English verse, 8vo; 2. The French Gardener, 12mo; 3. *Fumifugium*, or the Inconveniences of the Air and Smoke of London dissipated, 4to; 4. Sculpture, or the History and Art of Chalcography and Engraving in Copper, 8vo; 5. *Sylva*, or a Discourse of Forest Trees; to which is added Pomona, concerning Fruit Trees, folio. In 1776 a new edition of the *Sylva* was published by Dr Hunter of York, and again in 1812. 6. A Parallel of the Ancient Architecture with the Modern, folio; 7. *Calendarium Hortense*, or the Gardener's Almanac, 8vo; 8. Public Employment and an Active Life preferred to Solitude, 8vo; 9. An Idea of the Perfection of Painting, 8vo; 10. A Discourse on the History of Trade and Navigation; 11. *Terra*, a Philosophical Discourse of Earth, 8vo; 12. *Numismata*, or a Discourse of Medals, folio. The Memoirs of Evelyn, comprehending an interesting diary and correspondence, were published in 1819, 2 vols. 4to, and more recently in 5 vols. 8vo. His miscellaneous works have also been collected and given to the public. They include treatises on gardening, architecture, medals, &c. besides a curious tract entitled *Mundus Muliebris; or the Ladies' Dressing Room unlocked, and the Toilette spread, in burlesque; together with the Fop's Dictionary, or Catalogue of Hard Names and Terms of the Art Cosmetick*, first printed in 1690.

EVERGETES, or EUERGETES, a surname signifying *benefactor*, given to Philip of Macedonia, to Antigonus Doson, and to Ptolemy of Egypt. It was also commonly applied to the kings of Syria and Pontus; and we often find among the former an Alexander Evergetes, among the latter a Mithridates Evergetes. Some of the Roman emperors also claimed the title of Benevolent.

EVESHAM, a market and borough town of Worcestershire, in the hundred of Blakenhurst, 96 miles from London. It is finely situated in the midst of the rich vale of the same name, on both sides of the river Avon. A great number of market gardeners in the vicinity raise large quantities of the rarer vegetables, but especially of asparagus, for the supply of Oxford, Birmingham, and other large towns. It returns two members to parliament, chosen by the freemen. The market is held on Monday. The population amounted in 1801 to 2837, in 1811 to 3068, in 1821 to 3487, and in 1831 to 3991.

EVIDENCE, in *Philosophy*, that perception of truth which arises either from the testimony of the senses or from an induction of reason.

EVIDENCE, in *Law*, signifies some proof by testimony of men upon oath, or by writings or records. See ENGLAND, Part III. *Government and Laws.*

EVIL, in *Philosophy*, is either moral or natural. Moral evil is the disagreement between the actions of a moral agent and the rule of those actions, whatever it is. Natural evil is whatever destroys or any way disturbs the perfection of natural beings, such as blindness, disease, and death.

King's EVIL, or *Scrofula.* See MEDICINE.

EVORA, a city of Portugal, in the province of Alemtejo. It is the seat of an archbishop, and is well fortified, though the fortifications are now of no possible use as means of defence. There is a most superb aqueduct, which conveys fresh water to the city from the distance of four or five miles. A college, or rather university, was established here in 1553; but it has gradually dwindled away, and is now almost extinct. This city contains 3000 houses and 12,000 inhabitants; and in its neighbourhood are many Roman ruins, particularly one of a temple to Diana. Lat. 38. 28. N.

EVREMOND, CHARLES DE ST DENIS, a polite scholar and soldier, was born at St Denis le Guast in Lower Normandy in 1613. He was intended for the profession of the law, and commenced study with this view; but he soon quitted it, and became an ensign before he was sixteen. A military life, however, did not prevent him from cultivating literature, and he signalized himself by his politeness and wit as much as by his bravery. The king made him a mareschal-de-camp, and gave him a pension of three thousand livres per annum. He served under the Duke of Candale in the war of Guienne, and in Flanders, till the suspension of arms was agreed on between France and Spain; and he afterwards accompanied Cardinal Mazarin when he went to conclude the peace with Don Louis de Haro, the king of Spain's first minister. He wrote, as he had promised, to the Marquis de Crequi, a long letter concerning this negotiation, in which he showed that the cardinal had sacrificed the honour of France to his own private interest, and rallied his eminence in a very satirical manner. This letter having fallen into the hands of the cardinal's friends some time after the death of that minister, it was represented as a state crime, and the author was obliged to fly to Holland. But he had too many friends in England, whither he had the year before accompanied the Count de Soissons, in order to compliment Charles II. upon his restoration, to make any long stay in Holland; and therefore he passed over into England, where he was received with great respect, admitted into the intimate friendship of several persons of distinction, and honoured with a pension of L.300 a-year. But he had a great desire to revisit his native country; and, after the peace of Nimeguen, he wrote a letter in verse to the king of France, to ask leave to return, but in vain. Upon the death of King Charles he lost the pension which had been conferred on him; and he did not rely much on King James, though that prince had been extremely kind to him. But the Revolution proved more advantageous to him than might have been expected. King William, who had known him in Holland, gave him substantial marks of favour. But he died of a stranguary in 1703, at the age of ninety, and was interred in Westminster Abbey, where a monument is erected to his memory. His behaviour was engaging, and his humour cheerful, but he had a strong disposition to satire. He professed the Roman Catholic religion, in which he was born; but at bottom he was believed to be a freethinker. He always spoke of his disgrace with the resolution of a gentleman; and however strong a desire he may have had to return to his country, he never solicited the favour with meanness; so that, when permission was unexpectedly granted to him in the decline of his life, he replied, that the infirmities of age did not permit him to leave a country where he had lived agreeably. There have been many editions of his works; but the best is that of Amsterdam in 1726, in 5 vols. 12mo, to which is prefixed his life by Dr des Maizeaux, who has also given an accurate English translation of them in 3 vols. 8vo.

EVREUX, an arrondissement of the department of the Eure, in France, extending over 1936 square miles. It comprehends eleven cantons and one hundred and twenty-two communes, inhabited by 122,401 inhabitants. The capital is a city of the same name, situated in a valley on the river Iton, some branches of which run through the streets. The town is well built, and has a fine Gothic cathedral and bishop's palace, the old castle of Navarre, and fine walks on what were once the ramparts. It contains 1094 houses and 9238 inhabitants, who are occupied in spinning twist, in making cotton, linen, and woollen goods, hosiery, paper, and leather. Long. 1. 3. 34. E. Lat. 49. 1. 24. N.

EWANPILLY, a Mahratta town and small port of Hindustan, in the province of Berar, 110 miles S.S.E. from Nagpoor. Long. 80. 55. E. Lat. 18. 50. N.

EWELL, a market-town of Surrey, in the hundred of Copthorne, thirteen miles from London. Near this town is the modernised ancient palace of Nonsuch, built by Henry VIII. and a favourite residence of Queen Elizabeth, but afterwards given by Charles II. to the Duchess of Cleveland. There is a market on Thursday, and a large annual fair, at which many thousand sheep are sold. The population amounted in 1801 to 1112, in 1811 to 1135, in 1821 to 1550, and in 1831 to 1851.

EX, or EXE, a river of England, which rises in a barren tract of land called Exmoor, in the county of Somerset, and after being enlarged by several accessions, passes Tiverton, Exeter, and Topsham. It next receives the waters of the Kew, and falls into the sea at Exmouth. This river is navigable by vessels of considerable burden to Topsham, and was so to Exeter formerly.

EXAGGERATION, in *Rhetoric*, a kind of hyperbole, by which things are augmented or amplified by saying more than the truth, either as to good or bad.

EXAGGERATION, in *Painting*, a method by which the artist, in representing things, changes them too much, or makes them too strong, either in respect of the design or the colouring. It differs from *caricaturing*, inasmuch as the latter perverts or gives a turn to the features of a face, or the figure, which they have not; whereas exaggeration only heightens or improves what they had.

EXALTATION, or ELEVATION, is chiefly used in a figurative sense, for the raising or advancing a person to some ecclesiastical dignity, particularly to the papacy.

EXALTATION of the Cross is a feast of the Roman Catholic church, held on the 14th of September, in memory, as is generally supposed, of the emperor Heraclius having brought back the true cross of Jesus Christ on his shoulders, in order to place it on Mount Calvary, from which it had been carried away fourteen years before by Cosroes, or Khusru, king of Persia, at his taking of Jerusalem, under the reign of the emperor Phocas. The cross was delivered up by a treaty of peace made with Siroe, the son and successor of Khusru. The institution of this treaty is commonly said to have been signalized by a miracle; inasmuch as Heraclius could not stir out of Jerusalem with the cross whilst he had the imperial vestments on, enriched with gold and precious stones, but bore it with ease in a common dress.

The feast of the dedication of the temple built by Constantine was, according to Nicodemus, held on the 14th of September, the day on which the temple had been consecrated in the year 335; and this feast was also called the *exaltation of the cross*, because it formed part of the ceremonial for the bishop of Jerusalem to ascend a high place, built for the purpose by Constantine, in manner of a pulpit, and called by the Greeks the *sacred mysteries of God*, or *the holiness of God*, and there to elevate the cross, that all the people might see it.

EXALTATION, in *Astrology*, is a dignity which a planet acquires in certain signs or parts of the zodiac, and which is supposed to give it an extraordinary virtue, efficacy, and influence. The opposite sign, or part of the zodiac, is called the dejection of the planet. Thus the 15th degree of Cancer is the exaltation of Jupiter, according to Albumazor, because it was the ascendant of that planet at the time of the creation; that of the sun is in the 19th degree of Aries, and its dejection in Libra; that of the moon is in Taurus; and so on.

EXAMINATION, an exact and careful search or inquiry, in order to discover the truth or falsehood of a thing.

Self-EXAMINATION is a point much insisted on by divines, and particularly the ancient fathers, by way of preparation for repentance. St Ignatius reduces it to five points, a returning thanks to God for his benefits; a begging of grace and light, to know and distinguish our sins; a running over all our actions, occupations, thoughts, and words, in order to learn what has been offensive to God; a begging of pardon, and conceiving a sincere sorrow for having displeased him; and making a firm resolution not to offend him any more, and taking the necessary precautions to preserve ourselves from sin.

EXARCH, in *Antiquity*, an appellation given by the emperors of the East to certain officers sent into Italy, in quality of vicars, or rather prefects, to defend that part of Italy which yet remained under their obedience, particularly the city of Ravenna, against the Lombards, who had made themselves masters of nearly all the rest of the country.

The residence of the exarch was at Ravenna, which city, together with that of Rome, was all that remained to the emperors. The first exarch was the patrician Boetius, famous for his treatise *De Consolatione Philosophiæ*, who was appointed in 568 by the younger Justin. The exarchs subsisted about 185 years, and ended with Eutychius, under whose exarchate the city of Ravenna was taken by the Lombard king Astulphus, or Astolphus.

The emperor Frederick created Heraclius, archbishop of Lyons, a descendant of the illustrious house of Montboissier, exarch of the whole kingdom of Burgundy; a dignity till that time unknown except in Italy, particularly in the city of Ravenna.

Homer, Philo, and other ancient authors, give the name *exarchus* to the choragus or master of the singers in the ancient choruses; the word *αρχω* or *αρχομαι* signifying equally to *begin* and to *commend*.

Exarch *of a Diocese* was, anciently, the same with primate. This dignity was inferior to the patriarchal, yet greater than the metropolitan.

Exarch also denotes an officer, still subsisting in the Greek church, being a kind of deputy or legate *a latere* of the patriarch, whose office it is to visit the provinces allotted him, in order to inform himself of the lives and manners of the clergy, and to take cognizance of ecclesiastical causes, the manner of celebrating divine service, the administration of the sacraments, particularly confession, the observance of the canons, monastic discipline, affairs of marriages and divorces, and, above all, the revenues which the patriarch receives from several churches, with the collection of the same. The exarch, after having greatly enriched himself in his post, frequently rises to the patriarchate itself.

Exarch is also used, in the ecclesiastical antiquities of the Eastern church, for a general or superior over several monasteries, as an archimandrite, who is exempted by the patriarch of Constantinople from the jurisdiction of the bishops, in the same manner as are the generals of the Roman Catholic monastic orders.

EXAUCTORATIO, in the Roman military discipline, differed from the *missio*, which was a full discharge, and took place after a soldier had served in the army twenty years; whereas the *exauctoratio* was only a partial discharge. The *exauctorati* lost their pay indeed, but still remained under their colours or *vexilla*, though not under the *aquila* or eagle, which was the standard of the legion; and hence, instead of *legionarii*, they were called *subsignani*, and were retained till they had either served their full time or had lands assigned them. The *exauctoratio* took place after a soldier had served seventeen years.

EXCALCEATION, amongst the Hebrews, was a particular law, by which a widow, whom her husband's brother refused to marry, had a right to summon him to a court of justice, and, upon his refusal, to excalceate him; that is, to pull off one of his shoes and spit in his face, both of which actions inferred great ignominy.

EXCELLENCY, a title anciently given to kings and emperors, but now to ambassadors, generals, and other persons, who are not entitled to that of *highness*, but yet are elevated above the other inferior dignities.

EXCENTRIC, in *Geometry*, a term applied to circles and spheres which have not the same centre, and consequently are not parallel; in opposition to concentric, where they are parallel, having one common centre.

EXCENTRICITY, in *Astronomy*, is the distance of the centre of the orbit of a planet from the centre of the sun; that is, the distance between the centre and the focus of the ellipse.

EXCESS, in *Arithmetic* and *Geometry*, is the difference between any two unequal numbers or quantities, or that which remains after the lesser is taken from the greater.

EXCHANGE.

In political economy the term exchange is commonly employed to designate that species of mercantile transactions by which the debts of individuals residing at a distance from each other are either partially or wholly liquidated, without the intervention of money. The object of this article is to explain the nature of these transactions, and the principles on which they are founded.

This will be best effected by treating, *first*, of the exchange between different parts of the same country; and, *secondly*, of that between different and independent countries.

Inland Exchange.

Inland exchange.

Suppose a merchant of London orders his agent in Glasgow to purchase and send to him a thousand pounds worth of cottons; then, although it should not suit the Glasgow merchant to commission goods of equal value from his London correspondent, the latter may nevertheless be under no necessity of remitting cash to Glasgow to discharge his debt. Among cities, or countries, having a considerable intercourse together, the debts mutually due by each other are found, in ordinary cases, to be nearly equal. And, therefore, the Glasgow merchant, who has shipped the cottons for London, does not transmit the bill drawn by him on his correspondent for their price directly to London to be cashed, for that would subject him to the expense of conveying the money home from London to Glasgow, but he gets its value from *some other merchant in Glasgow*, who has payments to make in London, on account of teas, wines, &c. imported from that city, and who, unless he could procure such a bill, would be obliged to remit their price in money. The bill on account of the cottons is, therefore, either drawn in favour of the person to whom the money for the tea and wine is owing in London, or it is drawn in favour of the tea merchant in Glasgow, and indorsed to him; and this last person, by presenting the bill to the purchaser of the cottons, receives its value, and consequently the price of the cottons, and the price, or part of the price, of his tea and wine, at the same moment. By this simple contrivance the expense and risk attending the double transmission, first, of money from London to Glasgow to pay the cottons, and, second, of money from Glasgow to London to pay the teas and wines, is entirely avoided. The debtor in one place is changed for the debtor in the other; and both accounts are settled without the intervention of a single farthing.

The bill drawn and negotiated in such a transaction as this is termed an *inland* bill of exchange. If the transaction had taken place between London or Glasgow and a foreign city, it would have been termed a *foreign* bill of exchange.

A bill of exchange may, therefore, be defined to be, "an order addressed to some person residing at a distance, directing him to pay a certain specified sum to the person in whose favour the bill is drawn, or his order."[1]

Circu stance which termi the pr of inl bills o chang

The price of bills of exchange fluctuates according to the abundance or scarcity of them in the market, compared with the demand. Thus, to revert to our former example, if we suppose the debts reciprocally due by London and Glasgow to be equal, whether they amount to L.10,000, L.100,000, or any other sum, they may all be discharged without the agency of money, and the price of bills of exchange will be at PAR; that is, a sum of L.100

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[1] In mercantile phraseology, the person who draws a bill is termed the *drawer;* the person in whose favour it is drawn the *remitter;* the person on whom it is drawn the *drawee*, and after he has accepted, the *acceptor*. Those persons into whose hands the bill may pass previously to its being paid, are, from their writing their names on the back, termed *indorsers;* and the person in whose possession the bill is at any given period, is termed the *holder* or *possessor*.

or L.1000 in Glasgow will purchase a bill for L.100 or L.1000 payable in London, and *vice versa*. But if these two cities are not mutually indebted in equal sums, then the price of bills of exchange will be increased in the city which has the greatest number of payments to make, and will be proportionally reduced in that which has the fewest. If Glasgow owe London L.100,000, whilst the debts due by London to Glasgow only amount to L.90,000, it is clear, inasmuch as the merchants of Glasgow have a larger sum to remit to London than the merchants of London have to remit to Glasgow, that the price of bills on London would rise in Glasgow, because of the increased competition; and that the price of bills on Glasgow would fall in London, because of the proportionally diminished competition. And hence a larger sum would be required to discharge any given amount of debt due by Glasgow, and a less sum would be required to discharge a corresponding amount of debt due by London; or, which is the same thing, the exchange would be in *favour* of London, and *against* Glasgow. Bills on London would sell in Glasgow for a *premium*, and bills on Glasgow would sell in London at a *discount*, the amount of the premium in the one case, and of the discount in the other, being obviously equal.

On the supposition that the balance of L.10,000, due by Glasgow, depressed the exchange of that city on London *one per cent.*, it would at first sight appear as if it would cost Glasgow L.101,000 to discharge its debt of L.100,000 due to London; and that, on the other hand, L.89,108 would be sufficient to discharge the debt of London to Glasgow. But a very little consideration will serve to show that this could not really be the case. No exchange transactions can take place between different cities, until there be both debtors and creditors of the one residing in the other. And hence, when the exchange became unfavourable to Glasgow, the premium paid by the Glasgow merchants for bills drawn on London would not go into the pockets of their creditors in that city, but into the pockets *of their neighbours in Glasgow, to whom London was indebted*, and from whom the bills had been purchased. The loss to Glasgow would, therefore, be limited to the *premium* paid on the balance of L.10,000. Thus, supposing that A of Glasgow owes D of London L.100,000, and that C of London owes B of Glasgow L.90,000; A will pay to B L.91,000 for a bill, or order, on C to pay D L.90,000. In this way, the L.90,000 London debt at Glasgow would be quite cleared off; the premium, which is lost by the debtor to London in Glasgow, being gained by its creditor in the same place. If the business had been transacted in London, C, with L.89,108, would have purchased of D a bill for L.90,000 payable by A, so that, in this case, the gain would have fallen to the share of the debtor C, and the loss to that of the creditor D, both of London. The complexity of real transactions does not affect the principles on which they are founded; and to whatever extent Glasgow might be indebted to London, or London to Glasgow, the only disadvantage under which either of them would in consequence be placed, would be the unavoidable one of paying the expense of remitting the *balance* of debt.

Natu limit fluct tions the exch ge.

The expense of transmitting money from one place to another forms the natural limit to fluctuations in the exchange. If 20s. sufficed to cover the expense and risk attending the transmission of L.100 from Glasgow to London, it would be indifferent to a Glasgow merchant, whether he paid one per cent. *premium* for a bill of exchange on London, or remitted money direct to that city. If the premium were less than one per cent. it would be clearly his interest rather to make his payments by means of bills of exchange than by remittances; and that it could not exceed one per cent. is obvious, for every individual would rather directly remit money, than incur an unnecessary expense, by purchasing a bill on London at a greater *premium* than would suffice to cover the expense of a money remittance. If, owing to the badness of the roads, to disturbances in the country, or to any other cause, the expense of remitting money from Glasgow to London should be increased, the difference in the rate of exchange between them *might* also be proportionally increased. But in every case, the extent to which this difference could attain would necessarily be limited by, and could not, for any considerable period, exceed, the cost of making remittances in cash.

Exchange transactions become more complex, when one place, as is very often the case, discharges its debts to another by means of bills drawn on a third place. Thus, although London should owe nothing to Glasgow, if Glasgow be indebted to London, London to Manchester, and Manchester to Glasgow; Glasgow would either wholly or partially discharge its debt to London by a bill drawn on Manchester. It would wholly discharge it, provided the debt due to Glasgow in Manchester was equivalent to the debt due by Glasgow to London. But if this be not the case, Glasgow must either remit money to London to discharge the *balance* of debt, or bills drawn on some other place indebted to her.

Transactions in inland bills of exchange are almost entirely conducted by bankers, who charge a certain rate per cent. for their trouble, and who, by having a credit in those places to which they are in the habit of remitting bills, are enabled, on all occasions, to supply the demands of their customers. In Great Britain, London, because of its intimate connection with other parts of the country, occasioned partly by its immense commerce, partly by its being the seat of government, and the place to which the revenue is remitted, and partly by its currency consisting of Bank of England paper, for which the paper currency of the country banks is rendered exchangeable, has become the great focus in which all the money transactions of the empire centre, and in which they are ultimately adjusted. In consequence of these various circumstances, but chiefly of the demand for bills on London to remit revenue, and of the superior value of Bank of England currency, the exchange between London and the other parts of the country is invariably in its favour. Bills on London drawn in Edinburgh and Glasgow were formerly made payable at forty days' date, which is equivalent to a *premium* of about one half per cent.; but, owing to the greater facility of communication, this *premium* is now reduced to twenty days' interest, or to about one fourth per cent. Bills for remitting the revenue from Scotland are now drawn at thirty days; previously to 1819 they were drawn at sixty days.

What has been already stated is sufficient to show, that, however well fitted bills of exchange may be for facilitating the operations of commerce, and saving the trouble and expense attending the transportation of money, it is impossible to adjust mercantile transactions by their means, except in so far as the accounts mutually balance each other. A *real* bill of exchange is merely an order entitling the holder to receive payment of a debt *previously contracted* by the person on whom it is drawn. It is essential to the existence of such a bill that an equivalent amount of debt should first be due. And hence, as the amount of the real bills of exchange drawn on any number of merchants cannot exceed the amount of their debts, if a greater sum be owing them than they owe to others, the *balance*, it is obvious, must either be paid in money, or by the delivery of some sort of commodities. If, as in the example just given, Glasgow owe London L.100,000, while London only owes Glasgow L.90,000, a reciprocal transfer of debts may be made to the extent of L.90,000. But the Glasgow merchants cannot discharge

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the additional L.10,000 by means of bills drawn on London; for, by the supposition, London only owed them L.90,000, and they have already drawn for its amount. The balance, therefore, must be discharged by an actual money payment, or by the delivery of some species of commodity, or by bills drawn on some third party who may be indebted to Glasgow.

Fictitious bills of exchange.

We do not mean by this to insinuate that there are no *fictitious* bills of exchange, or bills drawn on persons who are not really indebted to the drawer, in the market. In every commercial country, bills of this description are always to be met with; but they are only a device for obtaining loans, and do not and cannot transfer real debts. A merchant in London may form a connection with a merchant in Glasgow, and draw bills of exchange upon him payable a certain number of days after date, which the latter may retire by selling in Glasgow an equal amount of bills drawn upon his correspondent in London. The merchants who purchase, or the bankers who discount these bills, really advance their value to the drawers, who, as long as they continue, by means of this system of *drawing* and *redrawing*, to provide funds for their payment, continue in fact to command a borrowed capital equal to the amount of the fictitious paper in circulation. It is clear, however, that the negotiation of such bills has no effect in the way of transferring and settling the real *bona fide* debts reciprocally due between any two or more places. Fictitious bills mutually balance each other. Those drawn by London on Glasgow are exactly equal to those drawn by Glasgow on London, for the one set is drawn to pay the other—the second destroys the first, and the result is nothing.

The method of raising money by the discount or sale of fictitious bills, has been severely censured by Dr Smith, as entailing a ruinous expense on those engaged in it, and as being resorted to only by projectors, or persons of suspicious credit. When fictitious bills are drawn at two months' date, it is common, in addition to the ordinary interest of five per cent. to charge a commission of one half per cent., which must be paid every time the bill is discounted, or, at least, *six* times in the year. The total expense of money raised in this way could not, therefore, supposing the transaction to be always on account of the same individual, be estimated at less than eight per cent. per annum; and the payment of so high a rate of interest on borrowed capital, in a country where the ordinary rate of mercantile profit is only supposed to average from *six* to *ten* per cent., could not fail to be generally productive of ruin to the borrower. It seldom happens, however, that in transactions carried on by means of fictitious bills, the whole charge for commission falls on one individual. Loans obtained in this way are almost always on account of two or more persons. Thus, at one time a fictitious bill may be drawn by A of London on B of Glasgow; and, in this case, the Glasgow merchant will, before the bill becomes due, draw upon his London correspondent for the proceeds of the bill, including interest and commission. At another time, however, the transaction will be on account of B of Glasgow, who will then have to pay commission to his friend in London; so that each party may, on the whole, as Mr Thornton has observed, gain about as much as he pays in the shape of commission.

It is often extremely difficult to distinguish between a fictitious bill and one which has arisen out of a real mercantile transaction. Neither does it seem to be of any very material importance. The credit of the persons whose names are attached to the bills offered for discount, is the only real criterion by which either a private merchant or a banker can judge whether he ought to negotiate them. The circumstance of a merchant offering considerable quantities of accommodation paper for discount, ought, unquestionably, if discovered, to excite suspicions as to his credit. But unless in so far as the drawing of fictitious bills may be held to be indicative of over-trading, or of a deficiency of capital to carry on the business in which the party is engaged, there does not appear to be any good reason for refusing to discount them.

These few observations will, perhaps, suffice to explain the manner in which transactions between different parts of the same country are settled by means of bills of exchange. They are, in general, extremely simple. The uniform value of the currency of a particular country renders all comparison between the value of money at the place where the bill is drawn and negotiated with its value where it is to be paid, unnecessary; while the constant intercourse maintained amongst the different commercial cities of the same kingdom, by preventing those derangements to which the intercourse between distant and independent countries is always subject, prevents those sudden fluctuations which so frequently occur in the market price of foreign bills of exchange. We shall, therefore, leave this part of our subject, and proceed to investigate the circumstances which influence the course of exchange between different and independent countries.

Foreign Exchange.

The price of foreign bills of exchange depends entirely on two circumstances, *first*, on the value of the currency at the place where they are made payable, compared with the value of the currency at the place where they are drawn; and, *secondly*, on the relation which the supply of bills in the market bears to the demand.

If the real and nominal value of the currencies of the different nations having an intercourse together remained invariable, such fluctuations in the price of bills of exchange as arise from the first of these circumstances would be altogether unknown. But as the comparative value of the pound sterling, dollar, franc, guilder, florin, &c. is subject to perpetual variation, the price of bills of exchange must vary accordingly. Such variations, however, as proceed from this cause, affect merely their *nominal*, or rather numerical value. It is those only which arise from variations in the supply and demand for bills, or, which is the same thing, in the payments a country has to make compared with those it has to receive, that can be considered as *real*; and hence the distinctions of *nominal*, *real*, and *computed* exchange. The *first* depends on alterations in the value of the currencies compared together; the *second* depends on the supply of bills in the market compared with the demand; and the *third* or *computed* exchange depends on the combined effects of the other two. For the sake of perspicuity we shall treat of these separately.[1]

SECT. I.—NOMINAL EXCHANGE.

Bullion being everywhere recognised as the standard currency of the commercial world, the comparative value of the currencies of particular countries must depend, *1st*, on the value of bullion in those countries; and, *2dly*, on the *quantity* of bullion contained in their coins, or on the quantity of bullion for which their paper money, or other circulating media, will exchange.

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[1] Supposing every country to be in possession of its proper supply of bullion, the exchange may be said to be *nominally* affected by the amount of the difference between the market and mint price of bullion, and to be *really* affected by any deviation from par exceeding or falling short of that difference.

I. The real price of commodities being always proportioned not merely to the cost of their production, but also to the cost of their conveyance from where they have been produced to where they are to be made use of, it follows, that if the trade in the precious metals were perfectly free, and if the commodities produced in different countries were nearly all equally well fitted for exportation, the value of bullion in different countries would be chiefly regulated by their respective distances from the mines. Thus, on the supposition that neither England nor Poland had any other commodities except corn to exchange with the South Americans for bullion, it is evident that the precious metals would possess a greater value in Poland than in England, because of the greater expense of sending so bulky a commodity as corn the more distant voyage, and because of the greater expense of conveying the gold to Poland. If Poland, however, had succeeded in carrying her manufactures to a higher pitch of improvement than England, her merchants might be able, notwithstanding the disadvantage of distance, by exporting commodities possessed of great value in small bulk, and on which the expense of freight would be comparatively trifling, to sell bullion on cheaper terms than those of England. But if, as is actually the case, the advantages of skill and machinery were possessed by England, another reason would be added to that derived from her less distance from the mines, why gold and silver should be less valuable in England than in Poland, and why the money price of commodities should be higher in the former. (Ricardo, *Principles of Political Economy*, &c. 1st ed. p. 175.)

Hence, after nations have attained to different degrees of excellence in manufacturing industry, the value of bullion in different countries no longer depends entirely on their distance from the mines. But, whatever variations a different progress in the arts may occasion in the value of bullion in different countries, it is certain that it must always be less valuable in those into which it is imported, than in those where it is produced. Bullion, like every other commodity, *is exported to find, not to destroy its level.* And unless its value in Europe exceeded its value in America by a sum sufficient to cover the expenses attending its importation, and to yield the ordinary rate of profit to the importer, we should not, although the mines of Mexico and Peru were infinitely more productive, import from them a single ounce of bullion. It is obviously incorrect, therefore, to lay down as a general proposition, "that the par of exchange between two countries is that sum of the currency of either of the two, which, in point of intrinsic worth, is precisely equal to a given sum of the other, *that is, contains precisely an equal weight of gold and silver of the same fineness.*" (*Bullion Report*, p. 22, 8vo ed.) For a given quantity of gold and silver is not always, as is here assumed, of the same intrinsic value in different countries. It may not, indeed, differ very materially among nations in the immediate vicinity of each other, and which are all destitute of mines. But although, to use a familiar illustration, the value of sugar approaches nearly to a level in the great trading cities of Europe, it cannot surely be maintained that its value in the West Indies is the same with its value in Bordeaux or Liverpool, or that the exchange would be really at par, if a bill, which cost a hundred hogsheads of sugar in London, only brought a hundred in Jamaica. Now, this is precisely the case with bullion. Though the value of gold and silver, as compared with corn, labour, &c. may, and indeed must, vary very considerably among the different European nations, these variations are only the necessary result of their different progress in industry, and of the different quality of their cultivated lands, &c. Such differences of price are in the natural order of things; and bullion has only found its proper level when a quantity has been introduced into those countries which excel in manufactures, sufficient to raise the price of their corn and labour. These variations have, therefore, no effect on the exchange. An ounce of bullion in one country, notwithstanding this difference of price, will, because of the facility of intercourse, be very near equivalent to an ounce of bullion in another; and, supposing the trade in the precious metals to be perfectly free, the exchange will be at true par when bills are negotiated on this footing. But when we compare the values of the precious metals in distant countries, and especially in those where they are produced, with those into which they are imported, it is obvious they must differ considerably. Gold and silver, like iron, coal, tin, &c. are necessarily cheaper in countries possessed of extraordinarily productive mines, than in those possessed only of mines of a secondary degree of fertility, or when they have to be entirely imported from abroad. And the exchange between such places is not at true par, unless adequate allowance be made for this difference of value. Thus, if, because of the expense of carriage, the value of bullion in Great Britain is five per cent. greater than in Rio Jeneiro, a hundred ounces of pure gold in Rio Janeiro would not be worth a hundred ounces of pure gold in London, but five per cent. less; and the exchange would be at true par when bills for a hundred and five ounces of standard bullion payable in Rio Janeiro, sold in London for a hundred ounces.

The differences in the value of the precious metals in different countries have not been confined to those depending on their respective distances from the mines, or on their different progress in the arts. The opinion formerly so very prevalent, that gold and silver were the only articles that constituted real wealth, induced almost every commercial nation to fetter and restrict their exportation, and to adopt a variety of measures intended to facilitate their importation. But these regulations, even when most rigorously enforced, have been singularly ineffectual; the great value and small bulk of the precious metals rendering it not only extremely advantageous, but also comparatively easy, clandestinely to export them, whenever their relative value declined.

"When," says Dr Smith, "the quantity of gold and silver imported into any country exceeds the effectual demand, no vigilance of government can prevent their exportation. All the sanguinary laws of Spain and Portugal are not able to keep their gold and silver at home. The continual importations from Peru and Brazil exceed the effectual demand of those countries, and sink the price of these metals *below* their price in the neighbouring countries. If, on the contrary, in any particular country their quantity fell short of the effectual demand, so as to raise their price *above* that of the neighbouring countries, the government would have no occasion to take any pains to import them. If it were even to take the pains to prevent their importation, it would not be able to effect it. Those metals, when the Spartans had got wherewithal to purchase them, broke through all the barriers which the laws of Lycurgus opposed to their entrance into Lacedæmon. All the sanguinary laws of the customs are not able to prevent the importation of teas of the Dutch and Gottenburg East India Companies, because somewhat cheaper than those of the British Company. A pound of tea, however, is about a hundred times the bulk of one of the highest prices, 16s., that is commonly paid for it in silver, and more than two thousand times the bulk of the same price in gold, and is consequently just so many times more difficult to smuggle." (*Wealth of Nations*, vol. ii. p. 149.)

But, however ineffectual as a means of entirely preventing the egress of the precious metals, the restrictions on their exportation have nevertheless contributed to occasion some slight variations in their value in different countries. The risk incurred by the clandestine exporters of bullion from Spain is supposed to be equivalent to about two per cent.; or, which is the same thing, it is supposed that the restrictions maintain such an excess of gold and silver in that country as to sink their value two per cent. below their value in countries having a free trade in bullion. In calculating the true par of exchange between Spain and other countries, this circumstance must be taken into account. For to whatever extent the value of bullion in one country may be reduced below its value in those with which it maintains an intercourse, the nominal exchange must necessarily be unfavourable to that extent.[1]

It consequently results, that whatever occasions a rise or fall in the value of the precious metals in a particular country, must proportionally affect its nominal exchange with other countries. If more coin, or convertible paper, circulated in Great Britain, compared with the business it has to perform, than what circulates in other countries, its relative value would, in consequence, be diminished. Foreign bills would sell for a premium, the amount of which would be precisely equal to the excess of the value of the precious metals in the foreign market, caused by their redundancy in the home market; and, on the other hand, in the event of the currency becoming relatively deficient, its value would be proportionally increased;—bills drawn on foreign countries would sell at a discount, the amount of which would measure the excess of the value of the currency of this over that of other countries.

Manner of estimating the quantity of bullion contained in the coins of different countries.

II. In estimating the quantity of bullion contained in the currencies of different countries, a particular coin of one country, such as the British pound sterling, is selected as an *integer* or standard of comparison, and the proportion between it and the coins of other countries, supposing them to be of their *mint standard weight and fineness*, is ascertained by experiment. A par of exchange is thus established, or rather it is ascertained that a certain amount of the standard currency of a particular country contains precisely as much gold or silver of the same fineness, as is contained in the coin or integer with which it has been compared. This relation, or par as it is technically termed, is considered invariable; and allowance is made for subsequent variations in the quantities and purity of the bullion contained in the currencies of countries trading together, by rating the exchange at so much above or below par. In mercantile language, that country, by a comparison with one or other of whose coins the par of exchange has been established, is said to give the *certain* for the *uncertain*, and conversely. Thus, in the exchange between London and Paris, London and Hamburg, &c. London gives the *certain*, or the pound sterling, for an *uncertain* or variable number of francs, florins, &c. Hence, the higher the exchange between any two countries, the more is it in favour of that which gives the *certain*, and the lower, the more is it in favour of that which gives the *uncertain*.

On the supposition, which is very near the truth, that twenty-five francs contain the same quantity of standard bullion as a pound sterling (twenty-five francs, twenty centimes, is the exact par), and supposing also that the value of bullion is the same in both countries, the exchange between London and Paris will be at par, when a bill drawn by a merchant in the one on his correspondent in the other sells at that rate; that is, when a bill of exchange for 2500 or 25,000 francs payable in Paris, sells in London for L.100 or L.1000, and *vice versa*. It is but seldom, however, that the coins of any country correspond exactly with their mint standard; unless, when newly issued, they are all either more or less worn; and whenever this is the case, an allowance corresponding to the difference between the actual value of the coins and their mint value must be made in estimating "*the sum of the existing currency of either of two countries which contains precisely the same quantity of bullion as is contained in a given sum of the other.*" Thus, if the one pound sterling were so worn, clipped, rubbed, &c. as not to contain so much bullion as twenty-five francs, but ten per cent. less, the exchange between London and Paris would be at real par when it was nominally ten per cent. against London;[2] and if, on the other hand, the pound sterling was equal to its mint standard, while the franc was ten per cent. less, the exchange between London and Paris would be at real par when it was nominally ten per cent. against Paris and in favour of London. If the currency of both countries were *equally* reduced below the standard of their respective mints, then it is obvious there would be no variation in the real par. But whenever the currency of countries trading together is depreciated in an *unequal* degree, the exchange is nominally in favour of that country whose currency is least depreciated, and nominally against that whose currency is most depreciated.

It is almost unnecessary to refer to the history of exchange to show the practical operation of this principle; and we shall content ourselves with selecting the following, from an infinite number of equally conclusive instances.

In a pamphlet printed in 1604, but written in 1564, it is mentioned, that when Henry VIII. degraded the several species of coin then current, there began to be "*some disorder*" in the price of all wares and commodities, which Edward VI. attempted to remedy by diminishing still farther the quantity of pure silver contained in each coin; the consequence was, that *the English pound sterling, which heretofore exchanged abroad for twenty-six Flemish schillings, became worth no more than thirteen Flemish schillings*, the price of English commodities being at the same time proportionally increased. (Mr John Smith's *Memoirs of Wool*, vol. i. p. 105, 8vo. ed.)

Previously to the great re-coinage in the reign of William III., silver being at that time a legal tender, the *nominal* exchange between England and Holland, calculated according to the standard of their respective mints, was twenty-five per cent. against England; but inasmuch as English silver coins were then, owing to rubbing and clipping, depreciated more than twenty-five per cent. below their mint value, the real exchange may notwithstanding have been in favour of England. The circumstance of the *nominal* exchange having become favourable to this country as soon as the new coin was issued, renders this conjecture extremely probable. (*Wealth of Nations*, vol. ii. p. 215.)

Before the reformation of our gold coin in 1774, the guinea contained so much less than its standard weight as

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[1] All restraints on the exportation of the precious metals were abolished in Great Britain in 1819. Their effect for many years previous could not be estimated at above one fourth per cent.

[2] It is necessary to observe, that it is here supposed that the clipped or degraded money exists in such a degree of abundance as only to pass current at its bullion value. If the quantity of clipped money were *sufficiently limited*, it might, notwithstanding the diminution of weight, pass current at its mint value; and then the par would have to be estimated, not by its relative weight to foreign money, but by the mint price of bullion. This is a principle which must be constantly kept in view.

No al Exc ge.

to be degraded from two to three per cent. when compared with the current French coins, and the exchange between England and France was computed to be two or three per cent. *against* this country. Upon the reformation of the gold coin the exchange rose to par. The Turkish government, in the course of the last forty years, has made three great alterations in the value of its coin. Before these frauds were committed, the Turkish *piastre* contained nearly as much silver as the English *half crown;* and, in exchange, the par was estimated at *eight* piastres to the pound sterling. The consequence of these repeated adulterations has been, the reduction of the silver in the piastre to one half, and a fall in the exchange of 100 per cent.; bills on London having been bought in Turkey, in 1803, at the rate of sixteen piastres for every pound sterling.[1] Now, although it is not absolutely certain that these fluctuations in the *nominal* exchange were entirely owing to the alterations in the value of the coin, because the real exchange, or that which depends on the abundance or scarcity of bills in the market, might not be constant; yet the exact correspondence of the fall of exchange with the acknowledged degradation of the coin, renders it more than probable that it proceeded almost entirely from that degradation.[2]

Effec of varia ns in th lative lue of ld and s r on th x- chang

When one country uses gold as the standard of its currency, and another silver, the par of exchange between them is affected by every variation in the relative value of these metals. When gold rises in value compared with silver, the exchange becomes nominally favourable to that country which has the gold standard, and *vice versa.* And hence, in estimating the state of the exchange among countries using different standards, it is always necessary to advert to the comparative values of the metals selected for standards.

"For example," to use the words of Mr Mushet, "if 34 schillings 11 grotes and ¼ of Hamburg currency be equal in value to a pound sterling, or 20/21 of a guinea, when silver is at 5s. 2d. per oz. they can no longer be so when silver falls to 5s. 1d. or 5s. an oz. or when it rises to 5s. 3d. or 5s. 4d.; because a pound sterling in gold being then worth more or less silver, is also worth more or less Hamburg currency.

"To find the real par, therefore, we must ascertain what was the relative value of gold and silver when the par was fixed at 34s. 11¼g. Hamburg currency, and what is their relative value at the time we wish to calculate it.

"For example, if the price of standard gold was L.3. 17s. 10½d. per oz. and silver 5s. 2d., an ounce of gold would then be worth 15·07 ounces of silver, and twenty of our standard shillings would then contain as much pure silver as 34s. 11 grotes and ¼ Hamburg currency. But if the ounce of gold were L.3. 17s. 10½d. and silver 5s. (which it was on 2d January 1798), the ounce of gold would then be worth 15·57 ounces of silver. If L.1 sterling at par, therefore, be worth 15·07 ounces of silver, then at 15·57 it would be at three per cent. premium; and three per cent. premium on 34s. 11¼d. is 1 schilling 1 grote and 9/10, so that the par, when gold is to silver as 15·57 to 1, will be 36 schillings 1 grote and 1/10. The above calculation will be more easily made by stating as '15·07 : 34-11¼ :: 15·57 : 36-1 1/10.'"[3]

Nominal Exchange.

Effect of seignorage on the exchange.

As it is by their intrinsic worth as bullion that the values of the coins of particular countries is estimated in exchange, two coins of equal weight and purity are reckoned equivalent to each other, although the one should have been coined at the expense of the state, and the other charged with a *seignorage,* or duty on its coinage. Coins on which a *seignorage* is charged may, if not issued in excess, pass current in the country where they are coined, at a value so much higher than their value in bullion; but they will not pass at any higher value in other countries.[4]

Effect of variations in the value of paper currency on the exchange.

But the principal source of fluctuations in the nominal price of bills of exchange is to be found in the varying value of the *paper* currency of commercial countries. The disorders which universally arose in rude ages from the diminution of the quantity of standard bullion contained in the coins of different countries are now reproduced in another form, and often to a still more ruinous extent, in the depreciation of their paper currency.

The impossibility of retaining a comparatively large quantity of coin or bullion, or of convertible paper, in a particular country, effectually limited the issues of the Bank of England previously to the Restriction Act of 1797, and sustained the value of our currency on a par with that of other countries. When the bank issued less paper than was necessary for this purpose, the value of the currency becoming relatively great, it became profitable to import bullion, and to send it to the mint to be coined. And, on the other hand, when the bank issued too much paper, and thereby depressed its value relatively to gold, it became profitable to demand payment of its notes, and thereafter to export the species thus obtained either in the shape of coin or as bullion. In this way the bank was compelled to limit its issues when excessive, and, consequently, to put a stop to the demand for gold, by rendering its paper of equal value.

Had the Bank of England, subsequently to the restriction, issued only such quantities of paper as were required to sustain its value on a par with the value of gold, the act of 1797 would not have occasioned any real difference in our monetary system. But after the bank had been released from the obligation to pay its notes, it was not to be expected that it should be very careful about limiting their number. The restriction *enabled* the directors to exchange bits of engraved paper, worth perhaps not more than five shillings a quire, for as many, or the value of as many hundreds of thousands of pounds. And under such circumstances, the only thing to be wondered at is, not that paper money became depreciated, but that its value was not more degraded,—that a still greater quantity of bank-notes were not forced into circulation.

A country with an inconvertible paper currency, of which an undue quantity has been issued, is in the same situation as a country would be in were it possessed of a redundant gold and silver currency, and subjected to laws prohibiting the melting or exportation of the coin that were carried into full effect. Such a currency is necessa-

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[1] Il est impossible d'indiquer exactement le *pair* des monnoies Turques. On voit des pieces du même nom, et frappées la même année, qui different de 100 pour cent. dans leur valeur intrinsèque. (Storch, *Cours d'Economie Politique,* tom. vi. p. 336.)

[2] *Observations on the Principles which regulate the Course of Exchange,* by William Blake, Esq. p. 41.

[3] *An Inquiry into the Effects produced on the National Currency by the Bank Restriction Bill,* &c. by Robert Mushet, Esq.; second edit. p. 94.

[4] Previously to 1817, no seignorage had for a very long period been deducted from either the gold or silver coins of Great Britain; but in the great recoinage of that year the value of silver was raised from 5s. 2d. to 5s. 6d. an ounce, or nearly in the proportion of 6½ per cent. The gold coins, however, are still coined free of expense, and no variation has been made in their standard. The British mint proportion of silver to gold is now as 14 287/1000 to 1; that is, one ounce of standard gold bullion is rendered exchangeable for 14 287/1000 ounces of standard silver. In France the mint proportion of the two metals is as 15½ to 1; a seignorage being exacted of nearly ½d per-cent. on gold, and 1½ per cent. on silver.

Nominal Exchange.

rily confined to the country where it is issued; it cannot, when too abundant, diffuse itself generally amongst others. The level of circulation is destroyed; and the value of the currency becoming less than the value of the currency of other countries, the nominal exchange is rendered proportionally unfavourable.

Supposing that nothing but silver coin of the standard weight and purity (twenty-five francs of which would exchange for a pound sterling of the British mint standard) circulates at Paris, and that the circulating medium of London is composed entirely of paper only worth half its nominal value, or which is depreciated 100 per cent.; in that case the exchange between London and Paris would be at *real* par, when it was nominally cent. per cent. against London. Double the amount of such depreciated London currency would be required to purchase a bill of exchange on Paris where the currency retained its value, while half the former amount of Parisian currency would now suffice to purchase a bill payable in London. A depreciation of this sort would have exactly the same effects as an equal reduction in the value of metallic money. While paper money, depreciated 100 per cent. constituted our legal currency, a pound note, instead of being worth 25 francs, would only be worth $12\frac{1}{2}$; and the nominal or numerical value of the bills of exchange negotiated between this country and France would be regulated accordingly; that is, a bill of exchange for L.100 or L.1000 payable in London, would sell in Paris for 1250 or 12,500 francs, and conversely. If, while the currency of London remained steady at 100 per cent. below its mint value, Parisian currency should, either from the coins becoming deficient in weight, or because of an inordinate issue of paper money, become also depreciated, the *nominal* exchange would be rendered proportionally less unfavourable to London. On the hypothesis that the currency of Paris is depreciated 50 and that of London 100 per cent. the *nominal* exchange would be 50 per cent. against the latter, and so on. Thus it appears that the *nominal* exchange between any two or more places will always be adjusted according to the value of their currencies; being most favourable to that country whose currency approaches nearest to its mint standard, and most unfavourable to that whose currency is most degraded.

Exchange between Great Britain and Ireland subsequent to 1797.

The state of exchange between Great Britain and Ireland, subsequently to the restriction on cash payments in 1797, furnishes a striking proof of the effects which inordinate issues of paper have in depressing the exchange.

The nominal value of the Irish shilling having been raised from 12d. to 13d., or, which is the same thing, L.108. 6s. 8d. of Irish money having been rendered only equal to L.100 of British money, it followed, that when the exchange between Great Britain and Ireland was at $8\frac{1}{3}$ per cent. against the latter, it was said to be at par. In the *eight* years previous to 1797, when the paper currency both of England and Ireland was convertible into gold, the exchange between London and Dublin fluctuated from $7\frac{1}{2}$ to 9 per cent. that is, from $\frac{5}{6}$ per cent. in favour of Dublin, to $\frac{2}{3}$ per cent. against it. In September 1797 it was so low as 6 per cent., or $2\frac{1}{3}$ per cent. in favour of Dublin. The amount of Bank of Ireland notes in circulation in January 1797 was only L.621,917; but in April 1801 they had increased to L.2,286,471, and the exchange was then at 14 per cent., or $5\frac{2}{3}$ per cent. *against* Dublin. In 1803, the Bank of Ireland notes in circulation averaged L.2,707,956, and in October of that year the exchange rose to 17 per cent. that is, to $8\frac{2}{3}$ per cent. against Dublin!

The fact of the exchange between London and Dublin having fluctuated so very little from real par for eight years previous to the restriction, shows that the circulating medium of Great Britain and Ireland had then been adjusted nearly according to the wants of the two countries. But, in these circumstances, it was evidently impossible, supposing the value of British currency to remain stationary, that the quantity of Irish bank paper could be nearly *quintupled* in the short space of six years, without rendering the currency of Ireland comparatively redundant, and sinking its value below that of England. Had the Bank of England increased its notes nearly in the same ratio as the Bank of Ireland, then, as the currency of both countries would have been *equally depreciated*, the exchange between London and Dublin would have continued at par. But while the notes of the Bank of Ireland were increased from L.621,917 to L.2,707,956, or in the proportion of 1 to 4·3, those of the Bank of England were only increased from L.9,181,843 (their number on 7th January 1797), to L.16,505,272, or in the proportion of 1 to 1·8. If the Bank of England had not made this addition to its issues, the exchange would obviously have been still more unfavourable to Dublin.

In the debates on the Bullion Report, it was contended that the increase of Bank of Ireland paper could not be the cause of the exchange becoming unfavourable to Dublin, inasmuch as it had again become favourable to the latter, after the issues of the Bank of Ireland had been still further increased. Nothing, however, can be more inconclusive than such reasoning. To give it the least weight, it must be shown that the currency of Great Britain had in the interim retained its value, or that it had not been depreciated to the same extent as that of Ireland. Unless this be established, the circumstance that the exchange between London and Dublin came to par, while as many notes of the Bank of Ireland circulated as in the period of its greatest depression, will not authorise us to conclude that the increase of Irish bank paper was not the cause of the fall in the exchange previously to 1804. For it is obvious that the depreciation of Irish bank paper might be going on subsequently to 1804; and yet, supposing English bank paper had been depreciated still more rapidly, the exchange would become more favourable to Dublin. This is merely supposing the circumstances which took place in the first six years of the restriction to be reversed in the second six. Let us examine how the fact stands.

We have seen that, in 1803, when the exchange was nominally ten per cent. against Dublin, the issues of the Bank of England amounted to L.16,505,272, and those of the Bank of Ireland to L.2,707,956. And, by referring to the account of the issues of the Bank of Ireland from 1797 to 1819, annexed to the article MONEY in this work, it will be seen that, in 1805, 1806, 1807, and 1808, they were rather *diminished;* and that, in 1810, they only amounted to L.3,251,750, being an increase of not more than L.543,794 in the space of seven years, or at the rate of two and six-sevenths per cent. per annum; but in the same period (from 1803 to 1810) the issues of the Bank of England had increased from L.16,505,272 to L.22,541,523, or at the rate of five per cent. per annum. But this is not all. According to Mr Wakefield (*Account of Ireland*, vol. ii. p. 171), who has left no subject untouched which could throw light on the state of Ireland, there were *fifty* registered bankers in that country in 1804, and only *thirty-three* in 1810, of which fourteen were new houses, thirty-one of the old establishments having disappeared; and I believe," says Mr Wakefield, "*for the most part failed.*" This extraordinary diminution of the country paper of Ireland, for the reduction of the issues was at least proportional to the reduction in the number of banks, must have greatly raised its value, and would have countervailed a very great increase in the issues of the national bank. Now the very reverse of all this took place in Britain. In 1800 there were 386 country banks in this country; and in 1810, this number, instead of being diminished, as in Ireland, had increased to 721, having at least three times the number of notes in circulation in the latter as in the former period!

It appears, therefore, that when, in the period between 1797 and 1804, the quantity of paper in circulation in Ireland was increased, and consequently its value depressed, faster than in England, the exchange between London and Dublin became proportionally unfavourable to the latter; and, on the other hand, it appears, that when, in the six years subsequent to 1804, the paper currency of England was increased more rapidly than the paper currency of Ireland, its relative value was diminished, and the *nominal* exchange became more favourable to Dublin.

This is sufficiently conclusive; but there is still more decisive evidence to show that the unfavourable exchange of Dublin upon London in 1802, 1803, 1804, &c. was entirely owing to the comparative redundancy or depreciation of Irish bank paper. The linen manufacturers, weavers, &c. and the majority of the other inhabitants of a few counties in the north of Ireland, being, at the period of the restriction, strongly disaffected towards government, almost unanimously refused to receive bank notes, either in payment of commodities or as wages. The landlords, having also stipulated for the payment of their rents in specie, the consequence was, that a gold currency was maintained in the north of Ireland long after it had been entirely banished from the southern part of the island. If, therefore, the depressed state of the exchange between London and Dublin had been occasioned, as was contended by the advocates of the restriction, by an unfavourable balance of trade between Ireland and Great Britain, or by remittances from the former on account of absentee landlords, &c. it would have been equally depressed between London and the commercial towns in the northern counties. But, so far from this being the case, in December 1803, when the exchange of Dublin on London was at sixteen and one-fourth per cent. that of Belfast on London was at five and one-fourth; or, in other words, at the same time that the exchange between Dublin and London was about eight per cent. against Ireland, the exchange between Belfast, *which had a gold currency*, and London, was about three per cent. in its *favour*. Nor is this all. There was not only a difference of eleven per cent. in the rate of exchange between Dublin and London, and Belfast and London, but the *inland* exchange between Dublin and Belfast was, at the same time, about ten per cent. in favour of the latter; that is, bills drawn in Dublin, and payable in the gold currency of Belfast, brought a premium of ten per cent.; while bills drawn in Belfast, and made payable in the paper currency of Dublin, sold at ten per cent. discount.[1]

It is unnecessary to refer to the history of the French *assignats*, or of the paper currency of the continental powers generally, and of the United States, to corroborate what has been advanced. Such of our readers as wish for detailed information as to these points may have recourse to the fourth volume of the *Cours d'Economie Politique* of M. Storch, where they will find an able and instructive account of the effects produced by the issues of paper on the price of bullion and the exchange, in almost every country of Europe. They are, in every case, precisely similar to those now stated.

It only remains to determine the effects of fluctuations in the *nominal* exchange, on the export and import trade of the country.

Inquiry into the effects of fluctuations in the nominal exchange on export and import trade.

When the exchange is at par, the operations of the merchant are regulated entirely by the difference between foreign prices and home prices. He imports those commodities which can be sold at home for so much more than their price abroad as will indemnify him for the expense of freight, insurance, &c. and yield an adequate remuneration for his trouble, and for the capital employed in their importation; and he exports those whose price abroad is sufficient to cover all expenses, and to afford a similar profit. But when the *nominal* exchange becomes unfavourable to a particular country, the premium which its merchants receive on the sale of foreign bills has been supposed capable of enabling them to export with profit in cases where the difference between the price of the exported commodities at home and abroad might not be such as would have permitted their exportation had the exchange been at par. Thus, if the *nominal* exchange were ten per cent. against this country, a merchant who had consigned goods to his agent abroad would receive a premium of ten per cent. on the sale of the bill; and if we suppose freight, insurance, mercantile profit, &c. to amount to six or seven per cent. it would at first sight appear as if our merchants might, in such circumstances, export commodities although their price at home were three or four per cent. higher than in other countries. If, on the other hand, the *nominal* exchange were in our favour, or if bills *on* this country sold at a premium, it would appear as if foreigners would then be able to consign goods to our merchants, or our merchants to order goods from abroad, when the difference of real prices was not such as would of itself have led to an importation.

But a very little consideration will convince us that fluctuations in the *nominal* exchange can have no such effect. That fall in the value of the currency which renders the exchange unfavourable, and causes foreign bills to sell at a premium, must *equally increase* the price of all commodities. And hence, whatever might be the amount of the premium which the exporter gained by the sale of the bill drawn on his correspondent abroad, it would do no more than indemnify him for the enhanced price of the goods exported. Mercantile operations are in such cases conducted precisely as they would be were the exchange really at par; that is, by a comparison of the real prices of commodities at home and abroad, meaning, by real prices, the prices at which they would be sold provided there were no depreciation of the currency. If those prices be such as to admit of exportation or importation with a profit, the circumstance of the nominal exchange being favourable or unfavourable will make no difference whatever on the transaction.

"Suppose," says Mr Blake, who has very successfully illustrated this part of the doctrine of exchange, "the currencies of Hamburg and London being in their due proportions, and therefore the *nominal* exchange at par, that sugar, which, from its abundance in London, sold at L.50 per hogshead, from its scarcity at Hamburg would sell at L.100. The merchant in this case would immediately export. Upon the sale of his sugar he would draw a bill upon his correspondent abroad for L.100, which he could at once convert into cash by selling it in the bill market at home, deriving from this transaction a profit of L.50, under deduction of the expenses of freight, insurance, commission, &c. Now, suppose no alteration in the scarcity or abundance of sugar in London and Hamburg, and that the same transaction were to take place after the currency in England had been so much increased that the prices

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[1] Farther information on this interesting subject may be obtained from the very able *Report of the Committee of the House of Commons*, appointed in 1804 to inquire into the state of the circulating paper in Ireland, its specie, &c. and the state of the exchange between it and Great Britain; in Sir Henry Parnell's excellent pamphlet on the same subject; and in the pamphlets of Lord King, Mr Huskisson, &c.

Nominal Exchange.

were doubled, and, consequently, the *nominal* exchange 100 per cent. in favour of Hamburg, the hogshead of sugar would then cost L.100, leaving apparently no profit whatever to the exporter. He would, however, as before, draw his bill on his correspondent for L.100; and, as foreign bills would bear a premium of 100 per cent. he would sell this bill in the English market for L.200, and thus derive a profit from the transaction of L.100 depreciated, or L.50 estimated in undepreciated currency, deducting, as in the former instance, the expense of freight, insurance, commission, &c.

"The case would be precisely similar, *mutatis mutandis*, with the importing merchant. The unfavourable *nominal* exchange would appear to occasion a loss amounting to the premium on the foreign bill which he must give in order to pay his correspondent abroad. But if the difference of *real* prices in the home and foreign markets were such as to admit of a profit upon the importation of produce, the merchant would continue to import, notwithstanding the premium; for that would be repaid to him in the advanced *nominal* price at which the imported produce would be sold in the home market.

"Suppose, for instance, the currencies of Hamburg and London being in their due proportions, and, therefore, the *nominal* exchange at par, that linen, which can be bought at Hamburg for L.50, will sell here at L.100. The importer immediately orders his correspondent abroad to send the linen, for the payment of which he purchases at L.50 a foreign bill in the English market, and on the sale of the consignment for L.100, he will derive a profit amounting to the difference between L.50 and the expense attending the import.

"Now, suppose the same transaction to take place without any alteration in the scarcity or abundance of linen at Hamburg and London, but that the currency of England has been so augmented as to be depreciated to half its value, the *nominal* exchange will then be 100 per cent. against England, and the importer will not be able to purchase a L.50 foreign bill for less than L.100. But as the prices of commodities here will have risen in the same proportion as the money has been depreciated, he will sell his linen to the English consumer for L.200, and will, as before, derive a profit amounting to the difference between L.100 depreciated, or L.50 estimated in undepreciated money, and the expenses attending the import.

"The same instances might be put in the case of a favourable exchange; and it would be seen in the same manner that *nominal* prices and the *nominal* exchange being alike dependent on the depreciation of currency, whatever apparent advantage might be derived from the former would be counterbalanced by a loss on the latter, and *vice versa*." (*Observations*, &c. p. 48.)

It appears, therefore, that fluctuations in the *nominal* exchange have no effect on export or import trade. A fall in the exchange obliges the country to which it is unfavourable to expend a larger *nominal* sum in discharging a foreign debt than would otherwise be necessary; but it does not oblige it to expend a greater *real* value. The depression of the *nominal* exchange can neither exceed nor fall short of the comparative depreciation of the currency. If the depreciation of British currency amounted to 10 or 100 per cent. the *nominal* exchange would be 10 or 100 per cent. against us; and we should be compelled, in all our transactions with foreigners, to give them 22s. or 40s. for what might otherwise have been procured for L.1. But as neither 22s. nor 40s. of paper, depreciated to the extent of 10 or 100 per cent. would be more valuable than L.1 of undepreciated paper, payment of a foreign debt might, it is evident, be as easily made in the one currency as in the other; and mercantile transactions would, in such circumstances, be conducted exactly as they would have been had the currency been undepreciated, and the *nominal* exchange at par.

It is necessary, however, before dismissing this part of our subject, to examine the effects of fluctuations in the *nominal* exchange on the importation and exportation of *bullion*. In certain cases they form an exception to the general principle we have been endeavouring to elucidate.

If the *nominal* exchange were unfavourable to a country which had entirely discarded the precious metals from its circulation, Mr Blake's opinion that the fall of the exchange has no effect on the export and import of bullion, more than of any other commodity, would be perfectly well founded. In this case the price of all sorts of commodities, and of bullion among the rest, would be increased precisely according to the depreciation of the currency; and the merchants who should, under such circumstances, attempt to export bullion, would find that its increased price in the home market would be exactly equivalent to whatever premium they might gain by the sale of the bills drawn on their agents abroad for its price. But when the *nominal* exchange becomes unfavourable to a country whose currency consists entirely of the precious metals, or partly of them and partly of paper, a different effect is produced.

In this case the depreciation necessarily adds to the stock of bullion in the country. For as soon as the currency has been depreciated to such an extent as to render the excess of the market above the mint price of bullion sufficient to cover the very trifling expenses attending the melting of the coin, and to afford some little remuneration for the trouble of the melters, they immediately set about converting it into bullion. If, indeed, it were possible to realize a greater profit by the exportation than by the fusion of the coins, they would not be converted into bullion, and, of course, its real price would continue stationary. But this is very seldom the case. The operation of melting is so extremely simple, and requires so very little apparatus, that it may, in almost every instance, be carried on at a less expense than would be necessary to export the coins. The cost attending the conveyance of gold to Paris varies in a season of peace, from one to two per cent.; while a profit of one fourth or one half per cent. is sufficient to indemnify the melters of guineas or sovereigns. It is obvious, therefore, that of the two modes of restoring the value of the currency when it becomes depreciated, or relatively redundant, that of fusion will be generally resorted to in preference to exportation. Should the redundancy of the currency be inconsiderable, all the addition which the operations of the melters could make to the supply of bullion, would most probably be insufficient to occasion any perceptible fall in its *real* price. But, in every case in which the redundancy or depreciation of the currency is considerable, the fusion of the coined money never fails to increase the quantity of bullion beyond the effectual demand, and, consequently, to occasion a fall in its *real* price, and to render it a profitable article of export. The demand for bullion, though it must always vary with the varying wealth and riches of the community, fluctuates very little in periods of limited duration; and no considerable addition can ever be made to the stock on hand in a particular country, without sinking its value and causing its egress.

Mr Blake contends that this exportation of bullion is the effect of the melting of the coin, and not the cause of it; and in so far he is certainly right. But we do not see how this in the least strengthens his opinion, that fluctuations in the *nominal* exchange, even in those cases in which the currency consists either wholly or partially of the precious metals, have no influence on the export and import of bullion. Surely it is impossible to deny that the fusion of the

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coin, of which Mr Blake admits the exportation of bullion is a necessary consequence, is occasioned by a redundancy of the currency, or by the same cause which occasions an unfavourable *nominal* exchange.

Bullion, therefore, forms an exception, and it is the only one, to the general principle that a fall in the value of the currency, or an unfavourable *nominal* exchange, has no effect on importation or exportation. But this exception does not take place, except in those cases in which the currency consists either in *whole* or in *part* of the precious metals. When the currency consists *entirely* of paper, or of any commodity other than gold or silver, its depreciation has no influence whatever on the importation of bullion.

SECT. II.—REAL EXCHANGE.

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Having thus endeavoured to trace the effects which variations in the value of the currencies of countries maintaining an intercourse together have on the exchange, we now proceed to consider how far it is influenced *by fluctuations in the supply and demand for bills.* To facilitate this inquiry, we shall exclude all consideration of changes in the value of money; or, which is the same thing, we shall suppose the currencies of the different countries having an intercourse together to be all fixed at their mint standards, and that each has its proper supply of bullion.

When two nations trade together, and each purchases from the other commodities of precisely the same value, their debts and credits will be equal, and, of course, the real exchange will be at par. The *bills* drawn by the one are, in such a case, exactly equivalent to those drawn by the other, and their respective claims may be adjusted without the transfer of bullion, or other valuable produce. But it very rarely happens that the debts reciprocally due by any two countries are equal. There is almost always a balance owing on one side or other; and this balance must affect the exchange. If the debts due by London to Paris exceeded those due by Paris to London, the competition in the London market for bills on Paris would, because of the comparatively large sum which our merchants had to remit to France, be greater than the competition in Paris for bills on London; and, consequently, the *real* exchange would be in favour of Paris and against London.

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The expense of the transfer of bullion from one country to another constitutes the limit within which the rise and fall of the *real* exchange between them must be confined. In this respect, as in most others, transactions between foreign countries are regulated by the very same principles which regulate those between different parts of the same country. We have already shown how the fluctuations in the *real* exchange between London and Glasgow could never exceed the expense of transmitting money between those cities. The same principle holds universally. Whatever may be the expense of transmitting bullion,—the money of the commercial world,—between London and Paris, Hamburg, New York, &c., it is impossible that the *real* exchange of the one on the other should, for any considerable period, be depressed to a greater extent. For a merchant will not pay a greater premium for a bill to discharge a debt abroad, than would suffice to cover the expense of transmitting bullion to his creditor.

Hence it appears that whatever has a tendency to obstruct or fetter the intercourse among different countries, must also tend to widen the limits within which fluctuations in the *real* exchange may extend. This enables us to account for its varying so much more in time of war than in time of peace. The amount of the bills drawn on a country engaged in hostilities is, from various causes which we shall afterwards notice, liable to be suddenly increased, though it is certain that whatever may be the amount of the bills thus thrown upon the market, the depression of the exchange cannot, for any length of time, exceed the expense of conveying bullion from the debtor to the creditor country. But during war this expense is increased; the charges on account of freight, insurance, &c. being then necessarily augmented. It appears, from the evidence annexed to the *Report of the Bullion Committee*, that the expense of conveying gold from London to Hamburg, which, prior to the war, only amounted to two or two and a half per cent. had, in the latter part of 1809, increased to about seven per cent.; showing that the limits within which fluctuations in the real exchange were confined in 1809 were about three times as great as those within which they were confined in 1793.

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This principle also enables us to account for the greater steadiness of the real exchange between countries in the immediate vicinity of each other. The expense of transmitting a given quantity of bullion from London to Dublin or Paris, is much less than the expense of transmitting the same quantity from London to New York or Petersburg. And, as fluctuations in the *real* exchange can only be limited by the cost of transmitting bullion, they may consequently extend much farther between distant places than between those that are contiguous.

Inquiry into the circumstances which give rise to a favourable or an unfavourable balance of payments.

It will now be proper to investigate the circumstances which give rise to a favourable or an unfavourable balance of payments, and to appreciate their effects on the real exchange, and on the trade of the country in general. As this is one of the most important inquiries in the whole science of political economy, it will require to be discussed at some length.

The fact that the value of the imports exceeds that of the exports, does not warrant the conclusion that the balance of payments is unfavourable.

A very great, if not the principal, source of the errors into which practical merchants, and the majority of writers on the subject of exchange, have been betrayed, appears to have originated in their confounding the sum which imported commodities are worth in the home market, with the sum which they cost in the foreign market. It is obviously, however, by the amount of the latter only, that the balance of payments, and consequently the *real* exchange, is influenced. A cargo of iron, for example, which cost L.1000 free on board at Gottenburg, might be worth L.1200 or L.1300 when imported into England; but the foreign merchant would not be entitled to draw on London for more than its original cost, or L.1000. It is clear, therefore, on the slightest consideration, that the circumstance of the value of the imports exceeding the value of the exports, does not authorise the conclusion that the balance of payments is unfavourable. A favourable or an unfavourable balance depends entirely on the sum due *to* foreigners for commodities imported from abroad being less or more than the sum due *by* them for the commodities they have purchased; but it has nothing to do with the prices eventually obtained for the imported or exported commodities.

The great object of the *mercantile* system of commercial policy, a system which still continues to preserve a considerable influence in this and in every other country in Europe, is, the creation of a favourable balance of payments, and consequently of a favourable *real* exchange, by facilitating exportation and restricting importation. It is foreign to the object of this article to enter into any examination of the principles of this system, except in so far as they are connected with the subject of exchange; but we hope to be able to show, in opposition to the commonly received opinions on the subject, that, under ordinary circumstances, the value of the imports must always exceed the value of the exports; and that this excess of importation has not, speaking generally, any tendency to render the *real* exchange unfavourable.

It is the business of the merchant to carry the various

In countries carrying on an advantageous commerce, the value of the imports must always exceed the value of the exports.

products of the different countries of the world from those places where their value is least, to those where it is greatest; or, which is the same thing, to distribute them according to the effective demand. It is clear, however, that there could be no motive to export any commodity, unless the commodity which it was designed to import in its stead was of greater value. When an English merchant orders a quantity of Polish wheat, he calculates on its selling for so much more than its price in Poland as will be sufficient to pay the expense of freight, insurance, &c.; and to yield, besides, the common and ordinary rate of profit on the capital employed in the business. If the wheat did not sell for this sum, its importation would obviously occasion a loss to the importer. No merchant ever did or ever will export, but in the view of importing a greater value in return. And so far from an excess of exports over imports being any criterion of an advantageous commerce, it is quite the reverse; and the truth is, notwithstanding all that has been said and written to the contrary, that unless the value of the imports exceeded that of the exports, foreign trade could not be carried on. Were this not the case—were the value of the exports always greater than the value of the imports, merchants would lose on every transaction with foreigners, and the trade with them would either not exist at all, or, if begun, would be speedily relinquished.

In England, the rates at which exports and imports are valued were fixed so far back as 1696. But the very great alteration that has since taken place, not in the value of money only, but in the cost of most part of the commodities produced in this and other countries, has rendered this *official* valuation, though valuable as a means of determining their quantity, of no use whatever as a criterion of the true value of the imports and exports. To obviate this defect, an account of the *real* or *declared* value of the exports is annually prepared from the declarations of the masters, and laid before parliament. There is, however, no such account of the imports; and, owing to the difficulties which high duties throw in the way, it is, perhaps, impossible to frame one with any thing like accuracy. It has also been alleged, and apparently with some foundation, that merchants have not unfrequently exaggerated the value of articles entitled to drawbacks on exportation; but the recent extension and improvement of the warehousing system, and the decrease in the number of drawbacks, must materially lessen whatever fraud or inaccuracy may have arisen from that source. Indeed, as most articles are charged with an *ad valorem* duty of 10s. per cent. on exportation, the fair presumption is, that their value will be underrated. We believe, however, that the declared value of the exports comes pretty near the truth, at least sufficiently so for all practical purposes.

But if perfectly accurate accounts could be obtained of the value of the exports and imports, there can be no manner of doubt that in ordinary years the latter would always exceed the former. The value of an exported commodity is estimated when it is shipped, *before* its value is increased by the expense incurred in transporting it to the place of its destination; but the value of the commodity imported in its stead is estimated *after* it has arrived at its destination, and, consequently, after it has been enhanced by the cost of freight, insurance, importer's profit, &c.

It is of very little importance, in so far at least as the interests of commerce are concerned, whether a nation act as the carrier of its own imports and exports, or employ others. A carrying nation appears to derive a comparatively large profit from its commercial transactions; but this excess of profit is nothing more than a fair remuneration for the capital it employs, and the risk it incurs, in transporting commodities from one country to another. Were the whole trade between this country and France carried on in British bottoms, our merchants, in addition to the value of the goods exported, would also receive the cost of their carriage to France. This, however, would not occasion any loss to that country. The French merchants must pay the freight of the commodities they import; and if the English can afford it on cheaper terms than their own countrymen, there is no good commercial reason, though there may be others of a different kind, why they should not employ them in preference.

In the United States the value of the imports, as ascertained by the customhouse returns, always exceeds the value of the exports. And although our practical politicians have been in the habit of considering the excess of exports over imports as the only sure criterion of an advantageous commerce, "it is nevertheless true, that the real gain of the United States has been nearly in proportion as their imports have exceeded their exports."[1] The great excess of American imports has been in part occasioned by the Americans generally exporting their own surplus produce, and consequently receiving from foreigners, not only an equivalent for their exports, but also for the cost of conveying them to the foreign market. "In 1811," says the author just quoted, "flour sold in America for nine dollars fifty cents per barrel, and in Spain for fifteen dollars. The value of the cargo of a vessel carrying 5000 barrels of flour would, therefore, be estimated, at the period of its exportation, at 47,500 dollars; but as this flour would, because of freight, insurance, exporter's profits, &c. sell in Spain for 75,000 dollars, the American merchant would be entitled to draw on his agent in Spain for 27,500 dollars more than the flour cost in America, or than the sum for which he could have drawn had the flour been exported on account of a Spanish merchant. But the transaction would not end here: the 75,000 dollars would be vested in some species of Spanish or other European goods fit for the American market; and the freight, insurance, &c. on account of the return cargo, would perhaps increase its value to 100,000 dollars; so that in all, the American merchant might have imported commodities worth 52,500 dollars more than the flour originally sent to Spain." It is as impossible to deny that such a transaction as this is advantageous, as it is to deny that its advantage consists entirely in the excess of the value of the goods imported over the value of those exported. And it is equally clear, that America might have had the balance of payments in her favour, though such transactions as the above had been multiplied to any conceivable extent.

Instead, therefore, of endeavouring to fetter and restrict the trade with those countries from which we should otherwise import a greater value than we exported, we ought to give it every possible facility. Every man considers that market as the best in which he is able to obtain the highest price, or the greatest value in exchange for his goods; why then should he be excluded from it? Why compel a merchant to dispose of a cargo of muslin for L.10,000 rather than L.12,000? The wealth of a state is made up of the wealth of individuals; and we have yet to learn that any more effectual method of increasing individual wealth can be devised than to permit every person to make his purchases in the cheapest and his sales in the dearest market.

It would be difficult to estimate the mischief which absurd notions relative to the balance of trade have occasioned in almost every commercial country. In Great Britain they have been particularly injurious. It is principally to the prevalence of prejudices to which they have given rise, that the restrictions imposed on the trade between this country and France are to be ascribed. The great, and, indeed, the only argument insisted on by those who prevailed on the legislature to declare the trade with France a *nuisance* (*Prohibition Act, 1st William and Mary*), was founded on the fact, that the value of the imports from that kingdom considerably exceeded the value of the exports. The balance was termed a *tribute* paid by England to France; and it was sagaciously asked, what had we done that we should be obliged to pay so much money to our deadly enemy? It never occurred to these wise persons, that no merchant would import any commodity from France, unless it brought a higher price in this country than the commodity exported in its stead; and that the profit of the merchant, or, which is the same thing, the national gain, would depend on this excess of price. The reason assigned for prohibiting the trade, affords the best proof of its having been a lucrative one. There cannot, indeed, be a doubt, that an unrestricted freedom of intercourse between the two countries would be of the greatest service to both. The peculiarities in the soil and climate, and in the national character of the people, of Great Britain and France, enable the one to produce various species of raw and manufactured commodities at a cheaper rate than they can be produced by the other. If we were allowed freely to purchase and import under moderate duties, the silks, the wines, and the brandies of France, those things which we can supply cheaper than our ingenious neighbours would be taken in payment. An extensive market would thus be created for a vast variety of articles, and a natural and powerful stimulus would be applied to the industry of both countries. Nobody denies that the trade with America, Portugal, and the Baltic is advantageous; and if so, why is the trade with France to be considered as prejudicial? Supposing the trade between the two countries were perfectly free, does any one imagine that our merchants would export or import any commodity to or from France, provided they could either sell or buy it on better terms anywhere else? If the restrictions on the French trade be not really injurious, that is, if the trade with France be either a losing or a less advantageous one than that with other countries, we may rest assured that the throwing it open would not make a single individual engage in it.

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[1] Pitkin on the *Commerce of the United States*, 2d ed. p. 280.

As the real price of commodities is always proportioned not only to the expense of their production, but also to the expense necessarily incurred in conveying them to the place where they are to be consumed, it is plain that a nation which prohibits trading with the countries in her vicinity must pay a higher price for her imported commodities, and be obliged to exact a higher price for those which she exports, than would be necessary were she able to procure the one or to dispose of the other in her immediate neighbourhood. If the same sort of wine could be bought at Bordeaux equally cheap as at Lisbon, the difference of freight would enable it to be sold cheaper in London. It is this principle, in fact, which renders the home trade peculiarly advantageous. The parties engaged in it live near each other, and consequently each obtains the commodity of which he stands in need at its cheapest rate, and without being obliged to pay any great additional sum on account of carriage. When, therefore, we restrict the trade with countries in our immediate vicinity, we act in the teeth of that very principle which is, in every other case, admitted to be advantageous. We compel such of our people as purchase foreign commodities, to buy them at a comparatively high price; while, by raising the price of the commodities we export, the market for them is injuriously contracted.

But the partisans of the exclusive or mercantile system will perhaps tell us, that they do not mean to contend that it is profitable to export a greater value than is imported, but that, by exporting an excess of raw and manufactured commodities, the balance of payments is rendered favourable, and that this balance (which they consider as representing the entire net profit made by the country on its transactions with foreigners) is always paid in *bullion*.

Favourable or unfavourable balance not always received or paid in bullion.

It will, however, be easy to show that this statement is altogether erroneous; that a balance, whether on the one side or the other, is seldom or never cancelled by means of bullion; and that this balance is not a measure, and has in fact nothing to do with the profit or loss attending foreign commercial transactions.

1. So long as the premium on foreign bills is less than the expense attending the transit of bullion from a country which has an unfavourable real exchange, no merchant ever thinks of subjecting himself to an unnecessary expense, by exporting bullion to pay a foreign debt. But though the premium on foreign bills had increased, so as to equal the cost of exporting the precious metals, for it cannot *exceed* this sum, it does not by any means follow that they would therefore be exported. That depends entirely on the fact, whether bullion be, at the time, the cheapest exportable commodity, or, in other words, whether a remittance of bullion be the most advantageous way in which a debt may be discharged. If a London merchant owe L.100 in Paris, he sets about finding out the cheapest method of paying it. On the supposition that the *real* exchange is two per cent. below par, and that the expense of remitting bullion, including the profit of the bullion merchant, is also two per cent., it will be indifferent to him whether he pay L.2 of premium for a bill of L.100 payable in Paris, or incur an expense of L.2, by remitting L.100 worth of bullion directly to that city. If the prices of cloth in Paris and London be such, that it would require L.103 to purchase and send as much cloth to Paris as would sell for L.100, he would undoubtedly prefer buying a bill or exporting bullion. But if, by incurring an expense of L.101, the debtor be able to send as much hardware to Paris as would sell for L.100, he would as certainly prefer paying his debt by an exportation of hardware. By doing so, he saves one per cent. more than if he bought a foreign bill or remitted bullion, and two per cent. more than if he exported cloth. If there had been any other commodity that might have been exported with more advantage, he would have used it in preference.

It is obvious, therefore, that the exportation of bullion is regulated by precisely the same principles which regulate the export and import of other commodities. It is exported when its exportation is most advantageous; that is, when it is less valuable at home and more valuable abroad than any other commodity; and it cannot be otherwise exported. The balance of payments might be a hundred millions against a country, without depriving it of a single ounce of bullion. No merchant would remit L.100 worth of gold or silver from England to discharge a debt in Paris, if he could invest L.98, L.99, or any smaller sum in any other species of merchandise which, exclusive of expenses, would sell in France for L.100. Those who deal in the precious metals are, we may depend upon it, as much under the influence of self-interest as those who deal in coffee or indigo. But who would attempt to discharge a foreign debt, by exporting coffee which cost L.100, if he could effect the same object by sending abroad indigo which cost only L.97? No person in his senses would export a hat to be sold for 20s. provided he could sell it at home for a guinea; nor would any person export an

Real Exchange.

ounce of bullion, if its value were not less in the exporting than in the importing country, or if there were any other commodity whatever that might be exported with greater advantage.

2. It is in vain to contend, that by permitting an unrestricted freedom of trade, one country might become indebted to another, which had no demand for any sort of ordinary merchandise, and which would only accept of cash or bullion in exchange for its exports. Such a case never did, and never will occur. A nation which is in want of money must also be in want of other things; for men only desire money because of its being the readiest means of increasing their command over the necessaries and enjoyments of life. The extreme variety, too, in the soil and climate, in the machinery, and in the skill and industry of the artisans belonging to different countries, must always occasion a considerable difference in the prices of their products. And until the cost of production be equalized, there must always be a foreign demand for those commodities which can be produced cheaper at home than abroad; and until the desire to accumulate be banished from the human breast, there must always be an inclination to send commodities from those countries where their exchangeable value is least, to where it is greatest.

3. In treating of the *nominal* exchange, we endeavoured to show, that it is impossible that any country should be able, for any length of time, to import or export a greater quantity of bullion than may be necessary to preserve the value of bullion in it in its proper relation to the bullion of other countries; or, which is the same thing, to have the *real* exchange either permanently favourable or unfavourable. But though this principle be strictly true in reference to its *aggregate* exchanges, it is incorrect when the state of its exchange with one country only is considered. Great Britain, for example, may constantly have the exchange in her favour with Portugal, provided she have it constantly, and to an equal extent, against her with the East Indies, or some other country. "She may," to use the words of Mr Ricardo, "be importing from the north the bullion which she is exporting to the south. She may be collecting it from countries where it is relatively abundant, for others where it is relatively scarce, or where, from some particular causes, it is in great demand. Spain, who is the great importer of bullion from America, can never have an unfavourable exchange with her colonies; and as she must distribute the bullion she receives among the different nations of the world, she can seldom have a favourable exchange with the countries with which she trades."[1]

It was by this principle that Lord King ingeniously, and, we think, successfully accounted for the nearly continued favourable exchange between this country and Hamburg, from 1770 to 1799. His Lordship showed that the importation of bullion from Hamburg and other countries was only equivalent to the quantity exported to the East Indies and consumed at home; that the demand corresponded to the supply; and that its value remained pretty stationary. The extraordinary influx of bullion into this country from the Continent at the era of the bank restriction in 1797, and the very favourable state of the exchange, were undoubtedly owing, in a very great degree, to the reduction in the issues of bank paper, and to the diminution of the gold currency caused by the hoarding of guineas, &c. In 1797 and 1798, above *five* millions of guineas were coined at the mint; and this extraordinary demand for gold is of itself abundantly sufficient to account for the very favourable exchange of that period, and for the length of time which it continued. But, at the same time that the demand for *gold* bullion for the mint was thus increased, the demand for *silver* bullion, for the purpose of exportation by the East India Company, had also been proportionally augmented. In 1795, the quantity exported on account of the Company, and of private persons, amounted to only 151,795 ounces.

In 1796 to............................290,777
1797...................................962,880
1798.................................3,565,691
1799.................................7,287,327

From this period the exportation of silver to the East Indies was very much reduced; and, in the years in which the exchange was most unfavourable, it had almost entirely ceased.

Instead, therefore, of the extraordinary importation of bullion from Hamburg in 1797 and 1798 affording, as Mr Bosanquet and others have supposed, a practical proof of the fallacy of the opinion of those who contend that it is impossible, for any length of time, to destroy the natural equality in the value of bullion in different countries, it is a striking example of its truth. Without this influx, bullion in this country could not have maintained its proper value, as compared with that of other countries. We imported it, because, owing to the reduction of the paper currency, and the increased exports by the East India Company, its value was rendered higher here than on the Continent; and, consequently, because the Continental merchants found it advantageous to send bullion to us, in the same manner as they would have sent corn, or any other commodity for which there happened to be an unusual demand in Great Britain. For, however favourable the *real* exchange between Hamburg and London might have been to the latter, we should not have imported a single ounce of bullion, had it not been, at the time, the most advantageous article with which Hamburg could discharge its debt to London.

4. In the absence of all other arguments, it would be sufficient to state, that it is physically impossible that the excess of exports over imports, as indicated by the custom-house returns, should be paid in bullion. Every country in the world, with the single exception of the United States, has its apparently favourable balance; and of course, if they really existed, they would have to be paid by an influx of bullion from the mines correspondent to their aggregate amount. It is certain, however, that the entire produce of the mines, though it were increased in a *tenfold* proportion, would be insufficient for this purpose! This of itself is decisive of the degree of credit which ought to be attached to the commonly received opinions on this subject.

5. In the last place, the profit on transactions with foreigners does not consist in the quantity of bullion imported from abroad, but in "the excess of the value of the imports over the value of the exports." If, in return for exported commodities worth *ten* or *twenty* millions, we import such as are worth *fifteen* or *thirty*, we shall gain 50 per cent. by the transaction, though the exports should consist entirely of bullion, and the imports of corn, sugar, coffee, &c. It is a ridiculous prejudice that would make us import bullion rather than any other commodity. But whatever the partisans of the exclusive system may say about its being a *preferable product*, a *marchandise par excellence*, we may be assured that it will never appear in

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[1] See *Reply to Mr Bosanquet's Observations on the Report of the Bullion Committee*, p. 17; one of the best pamphlets that has ever been published on the subject of exchange.

the list of exports or imports, while there is any other commodity with which to carry on trade that will yield a larger profit.

Thus it appears that the excess of exports over imports, instead of being any proof of an advantageous commerce, is distinctly and completely the reverse ;—that a commercial country may, and almost always does, import commodities of greater value than it exports, without rendering itself indebted to foreigners ;—and that when a balance of debt has been contracted, that is, when the sum *payable to* foreigners for imported commodities is greater than the sum *receivable from* them for exported commodities, the balance will not be paid by sending bullion from the debtor to the creditor country, unless it be at the time the most profitable article of export.

We have, in the previous *section*, shown that fluctuations in the nominal exchange have no effect on foreign trade. When the currency is depreciated, the premium which an exporter derives from the sale of the bill drawn on his correspondent abroad, is barely equivalent to the increase in the price of the goods exported, occasioned by the depreciation. But when the premium on a foreign bill is not a consequence of a fall in the value of money, but of a deficiency in the supply of bills, there is no rise of prices, and under such circumstances the unfavourable exchange undoubtedly operates as a stimulus to exportation. As soon as the *real* exchange diverges from par, the mere inspection of a price current is no longer sufficient to regulate the operations of the merchant. If it be unfavourable, the premium which an exporter receives on the sale of bills must be included in the estimate of the profit he is likely to derive from the transaction. The greater that premium, the less will be the difference of prices necessary to make him export. And hence an unfavourable *real* exchange has exactly the same effect as a bounty on exportation equal to the premium on foreign bills.

But for the same reason that an unfavourable *real* exchange increases exportation, it proportionally diminishes importation. When the exchange is really unfavourable, the price of foreign commodities brought to our markets must be so much under their price at home, as not merely to afford, exclusive of expenses, the ordinary profit on their sale, but also to pay the premium which the importer must give for a foreign bill, if he remit one to his correspondent, or for the discount, added to the invoice price, if the latter draw upon him. A much less quantity of foreign goods will therefore suit our markets when the *real* exchange is unfavourable ; and fewer payments having to be made abroad, the competition for foreign bills is diminished, and the *real* exchange rendered proportionally favourable. In the same way, it is easy to see that a favourable *real* exchange must operate as *duty* on exportation, and as a *bounty* on importation.

It is thus that fluctuations in the *real* exchange have a necessary tendency to correct themselves. They can never, for any considerable period, *exceed* the expense of transmitting bullion from the debtor to the creditor country. But the exchange cannot continue permanently favourable or unfavourable to this extent. When favourable, it corrects itself by restricting exportation and facilitating importation ; and when unfavourable, it produces the same effect by giving an unusual stimulus to exportation, and by throwing obstacles in the way of importation. The true PAR forms the centre of these oscillations ; and though the thousand circumstances that daily and hourly affect the state of debt and credit, prevent the ordinary course of exchange from being almost ever precisely at par, its fluctuations, whether on the one side or the other, are confined within certain limits, and have a constant tendency to disappear.

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The operations of the bill merchants have a tendency to lessen fluctuations in the *real* exchange.

The natural tendency which the exchange has to correct itself is powerfully assisted by the operations of the bill merchants.

England, for example, may owe an excess of debt to Amsterdam, yet, as the aggregate amount of the debts *due* by a commercial country, is generally balanced by the amount of those which it has to receive, the deficiency of bills on Amsterdam in London will most probably be countervailed by a proportional redundancy of them in some other quarter. Now, it is the business of the merchants who deal in bills, as of those who deal in bullion or any thing else, to buy them where they are cheap, and to sell them where they are dear. They therefore buy up the bills drawn by other countries on Amsterdam, and dispose of them in London ; and, by so doing, prevent any great fall in the price of bills on Amsterdam in those countries in which the supply exceeds the demand, and any great rise in Great Britain and those countries in which the supply happens to be deficient. In the trade between Italy and this country, the bills drawn on Great Britain amount almost invariably to a greater sum than those drawn on Italy. The bill merchants, however, by buying up the excess of the Italian bills on London, and selling them in France, Holland, and other countries indebted to England, prevent the *real* exchange from ever becoming very much depressed.

A large foreign expenditure has no permanent effect on the exchange.

An unusual deficiency in the supply of corn, or of any other article of prime necessity, the demand for which could not be immediately contracted, by causing a sudden augmentation of the imports from abroad, materially affects the state of debt and credit with foreign countries, and depresses the exchange. In time of war the balance of payments is liable to be still further deranged ; the amount of the bills drawn on a country carrying on foreign hostilities, being increased by the whole expense of its armaments abroad, and of subsidies to foreign powers. But neither the conjoined nor separate influence of both or either of these causes can exert any permanent influence over the exchange. A sudden increase in the accustomed supply of bills must, in the first instance, by glutting the market, occasion their selling at a discount ; but this effect can only be of temporary duration. The unusual facilities which are then afforded for the exportation of manufactured produce to the foreign market, and the difficulties which are thrown in the way of importation, never fail speedily to bring the *real* exchange to par.

In a period of profound peace we may, by exporting an excess of raw or manufactured produce, overload the foreign market, and occasion such a decline in the price of British goods abroad, as to render the imported less valuable than the exported commodities with which they have been purchased. But such a state of things speedily effects its own cure. The distress which it necessarily occasions leads to an immediate diminution of exports ; and the supply of British commodities in the foreign market being thus rendered more nearly commensurate with the demand, they of course sell for an adequate profit ; and the value of the imports again exceeds, as it always ought to do, the value of the exports. But whenever a country has a large foreign expenditure to sustain, its exports are proportionally augmented. Such an expenditure can only be discharged either by the government directly sending abroad an equivalent amount of commodities, or by means of bills of exchange drawn against produce exported by private individuals. Supposing the foreign expenditure of Great Britain during the late war to have amounted to ten or twenty millions a-year, it is evident we must have annually exported an equal amount of the produce of our land, capital, and labour, for which payment would be received, not, as in ordinary cases, by a corresponding importation of foreign commodities, but from the treasury at home. This is strictly true, even though it were admitted that the expenditure had, in the first instance, been entirely discharged by remittances of bullion; for the increased supply of bullion which was thus required could be obtained only by an equally increased exportation of other produce to the countries possessed of mines, or from which it could be advantageously imported. Foreign expenditure, by increasing exports precisely in proportion to its own amount, is incapable of exerting any permanent effect on the exchange.

Thus it appears that a *really* great excess of exports, instead of being any criterion of increasing wealth at home, is only a certain indication of great expenditure abroad. "When," says Mr Wheatley, "the exports exceed the imports, as they must do when there is a large foreign expenditure, the equivalents for the excess are received abroad in as full and ample a manner as if the produce which they purchased were actually imported and entered in the custom-house books, and afterwards sent to the seat of war for consumption. But from the circumstance of its not being inserted in the custom-house entries as value received against the produce exported for its payment, the latter is deemed to constitute a favourable balance, when it is in reality exported to liquidate a balance against us." (Wheatley *On the Theory of Money*, p. 219.)

Cause of the rise of the exchange in 1815 and 1816.

But however conclusive this reasoning may appear, it has nevertheless been contended, that it is at *variance with the fact;* and that the rise of the exchange in autumn 1814, and its restoration to par in 1816, when the restriction on cash payments at the bank was in full operation, is a practical and convincing proof that its previous depression had not been a consequence of the depreciation of the currency, but of the excessive supply of bills on London in the foreign market, occasioned by the expensive contest in which we were then engaged. According to our view of the matter, however, this fact leads to a precisely opposite conclusion. It is of no use to tell us that the exchange came to par while the restriction act was unrepealed. It was never contended that the fact of such law being in existence had any effect on the currency. The restriction was justly condemned, because it *enabled* the Bank of England to deluge the country with paper. If the bank had never abused that power,—if the proprietors had sacrificed their own individual interests to those of the public, and had constantly kept their paper on a level with bullion,—the restriction act, though unwise, would, as to consequences, have been the same as if it had never existed. The question is not, therefore, whether the exchange came to *par* while the restriction continued, but *whether it came to* PAR *while as many notes circulated as in the period of its greatest depression?* If this could be shown, and if it could also be shown that the effective demand for paper had not, at the same time, been proportionally increased, the argument would be conclusive; and we should be compelled to admit that a great comparative increase of paper money has no tendency to diminish its value, or to render the *nominal* exchange unfavourable!

But it would be worse than idle to set about proving by argument a fact so notorious as the prodigious diminution of bank paper in 1814, 1815, and 1816. In that period above 240 country banks stopped payment; and ninety-two commissions of bankruptcy were issued against these establishments; being at the rate of *one* commission against every *seven and a half* of the total number of banks existing in 1813! The Board of Agriculture estimated, that in the county of Lincoln alone above *three* millions of bank paper had been withdrawn from circulation; and the total diminution of the currency during the three years in question has seldom been estimated at less than from *sixteen* to *twenty* millions, though it probably amounted to a great deal more. Mr Horner, the accuracy and extent of whose information cannot be called in question, made the following statement on this subject, in his place in parliament:

"From inquiries he had made, and from the accounts on the table, he was convinced that *a greater and more sudden reduction of the circulating medium had never taken place in any country than had taken place since the peace in this country*, with the exception of those reductions that had taken place in France after the Mississippi scheme, and after the destruction of the assignats. The reduction of the currency had originated in the previous fall of the prices of agricultural produce. That fall had produced a destruction of country-bank paper, to an extent which would not have been thought possible, without more ruin than had actually ensued. The Bank of England had also restricted its issues. As appeared by the accounts recently presented, the average amount of its currency was not, during the last year, more than between L.25,000,000 and L.26,000,000; while two years ago it had been nearer L.29,000,000, and at one time even amounted to L.31,000,000. But without looking to the diminution of Bank of England paper, the reduction of the country paper was enough to account for the rise which had taken place in the exchange."

Here, then, is the cause of the exchange coming to par in 1815 and 1816. It had nothing to do with the cessation of hostilities, but was entirely a consequence of the increased value of our currency, caused by the sudden reduction of its quantity. Instead, therefore, of being at variance with the principles we have been endeavouring to elucidate, this fact affords the strongest confirmation of their perfect correctness. And having been sanctioned by the fullest experience, they may be considered as beyond the reach of cavil and dispute.

An objection of a different sort has been made, by a very able economist, to another part of the theory maintained in this *section*, of which it may here be proper to take some notice.

When the exchange becomes unfavourable, the premium, procured by the sale of the bill drawn on a foreign merchant to whom bullion has been consigned, is no greater than would be obtained by consigning to him coffee, tea, sugar, indigo, &c. of equal value. An unfavourable *real* exchange permits a merchant to export commodities which could not be exported were the *real* exchange at par, or favourable; but the advantage still remains of exporting those commodities in preference, whose price in the country from which they are exported, compared with their price in the country into which they are imported, is lowest. Suppose, for example, that the expense of transmitting bullion from this country to France is *three* per cent., that the *real* exchange is *four* per cent. against us, that the price of bullion is the *same* in both countries, and that coffee, exclusive of the expenses of carriage, is really worth *four* per cent. more in France than in England. In such a case, it is obvious, the exporter of bullion would realize only a profit of *one* per cent., while the exporters of coffee would realize, inclusive of the premium on the sale of the foreign bill, a profit of *seven* per cent. And hence the opinion maintained by Colonel Torrens (*Comparative Estimate*, &c.), that when the exchange becomes unfavourable, those commodities which contain the greatest value in the smallest bulk, or on which the expense of carriage is least, would be exported in preference, appears to rest on no good foundation. The prices of the commodities which nations trading together are in the habit of exporting and

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importing, are regulated not merely by the cost of their production, but also by the expense necessarily incurred in carrying them from where they are produced to where they are consumed. If Great Britain were in the constant habit of supplying France with corn and bullion, the average price of corn in France, because of the expense required to convey it from this country, would plainly be from ten to fifteen per cent. higher than in Britain; while, because of the comparative facility with which bullion might be transported from the one to the other, its value in Paris would not exceed its value in London more than one or two per cent. Now, supposing that when the prices of both corn and bullion in Great Britain and France are adjusted according to their natural proportions, the *real* exchange becomes unfavourable to us; it is clear, that this fall in the exchange gives no more advantage to the exporters of bullion than to those of corn. The rise in the price of foreign bills does not increase the expense attending the exportation of corn or bullion. It leaves the cost of producing and transporting these commodities exactly where it found it. During the depression of the exchange, the exporters of both articles derive a premium from the sale of the bills drawn on their foreign correspondents. But there can be no inducement to export bullion in preference to corn, unless the real price of bullion should increase more rapidly in France, or decline more rapidly in Great Britain, than the real price of corn.

Whatever, therefore, may be the depression of the exchange, the merchant invariably selects those commodities for exportation, which, exclusive of the premium, yield the greatest profit on their sale. If bullion be one of these commodities, it will of course be exported; if not, not. Bullion, however, of all commodities, is that of which the value approaches nearest to an equality in different countries, and hence it is the least likely to be exported during an unfavourable exchange. The demand for it is comparatively steady, and no great surplus quantity could be imported into one country without reducing its value, or exported from another without raising its value, so as to unfit it either for exportation or importation. A very small part only of an unfavourable balance is ever paid in bullion. The operations of the bullion merchant are chiefly confined to the distribution of the fresh supplies which are annually dug from the mines proportionally to the effective demand of different countries. Its price is too invariable, or, which is the same thing, its supply and demand are too constant, to admit of its ever becoming an important article in the trade between any two countries neither of which possesses mines.

In corroboration of this argument, we may mention that, according to the official statement laid on the table of the House of Commons, it appears that the expenses incurred by this country on account of the armies acting in Portugal and Spain during the following years, were as under:

In 1808	L.2,903,540
1809	2,450,956
1810	6,066,021
1811	8,906,700
1812 1813	31,767,794
1814	13,000,000

Of which, according to the same official statement, only the following sums were remitted in coin or bullion:—

In 1808	L.2,861,339
1809	461,926
1810	697,675
1811	748,053
1812 1813	3,284,435

Computed Exchange.

Of the sum of *five* millions voted to our allies in 1813 and 1814, not more than L.300,000 was sent in bullion, the rest being made up by the exportation of manufactured goods and military stores. (*Edinburgh Review*, vol. xxvi. p. 154.) The high market price of gold and silver in 1809, 1810, &c. could not, therefore, be owing to the purchases made by government, for they were not greater than the sums exported by the East India Company in 1798 and 1799, and in 1803, 1804, and 1805, when there was scarcely any perceptible rise in the price of bullion. The immense additions made to the paper currency of the country in 1809, 1810, &c. sunk its value compared with bullion, and was the true cause of the unfavourable *nominal* exchange of that period.

SECT. III.—COMPUTED EXCHANGE.

Computed exchange.

Having thus endeavoured to point out the manner in which variations in the comparative value of the currencies of nations trading together, and in the supply and demand for bills, separately affect the exchange, it now only remains to ascertain their combined effect. It is on this that the *computed* or actual course of exchange depends.

The computed exchange represents either the *sum* or the *difference* of the real and nominal exchange.

From what has been already stated, it must be obvious, that when the nominal and real exchange are both favourable or both unfavourable, the *computed* exchange will express their *sum;* and that when the one is favourable and the other unfavourable, it will express their *difference.*

When, for example, the currency of Great Britain is of the mint standard and purity, and the currency of France five per cent. degraded, the *nominal* exchange will be five per cent. in favour of this country. But the *real* exchange may, at the same time, be either favourable or unfavourable. If it be also favourable to the extent of one, two, three, &c. per cent. the computed exchange will be six, seven, eight, &c. per cent. in favour of this country. And, on the other hand, if it be unfavourable to the extent of one, two, three, &c. per cent. the *computed* exchange will be only four, three, two, &c. per cent. in our favour. When the *real* exchange is in favour of a particular country, provided the *nominal* exchange be equally against it, the *computed* exchange will be at par, and *vice versa.*

A comparison of the market with the mint price of bullion affords the best criterion by which to ascertain the state of the exchange at any particular period. When no restrictions are imposed on the trade in the precious metals, the excess of the market over the mint price of bullion affords a pretty accurate measure of the depreciation of the currency. If the market and mint price of bullion at Paris and London exactly corresponded, and if the value of bullion was the same in both countries, the *nominal* exchange would be at par; and whatever fluctuations the computed exchange might exhibit, must, in such a case, be traced to fluctuations in the *real* exchange, or, which is the same thing, to the supply and demand for bills. If, when the market price of bullion in Paris is equal to its mint price, it exceeds it ten per cent. in London, it is a proof that our currency is ten per cent. depreciated, and consequently the *nominal* exchange between Paris and London *must* be ten per cent. against the latter. Instead, however, of the *computed* or actual course of exchange being ten per cent. against London, it may be against it to a greater or less extent, or in its favour. It will be more against it provided the *real* exchange be also unfavourable,—it will be less against it provided the *real* exchange be in favour of London, though to a less extent than the adverse *nominal* exchange,—and it will be in fa-

Computed Exchange.

vour of London, should the favourable *real* exceed the unfavourable *nominal* exchange. Thus, if while British currency is ten per cent. depreciated, and French currency at par, the computed or actual course of exchange between Paris and London were twelve or fifteen per cent. against the latter, it would show that the *real* exchange was also against this country to the extent of two or three per cent. And if, on the other hand, the computed exchange was only five or six per cent. against London, it would show that the *real* exchange was four or five per cent. in its favour, and so on.

It has already been shown, that, in so far at least as the question of exchange is involved, the differences in the value of bullion in different countries are limited by the expense of its transit from one to another. And hence, by ascertaining whether a particular country exports or imports bullion to or from other countries, we are able to determine its comparative value in these countries. Suppose, for example, that the expense of conveying bullion from this country to France, including the profits of the bullion dealer, is two per cent.; it is clear, inasmuch as bullion is only exported *to find its level*, that whenever our merchants begin to export it to France, its value there must be two per cent. greater than in England; and, on the contrary, when they import bullion from France, it must be two per cent. more valuable here than in France. In judging of the exchange between any two countries, this circumstance must always be attended to. If no bullion be passing from the one to the other, we may conclude that its value is nearly the same in both; at all events, it is certain that the difference of its value is not greater than the expense of transit. On the supposition that the entire expense, including profit, &c. of conveying bullion from Rio Janeiro to London is five per cent., and that the London merchants are importing bullion, then it is clear, provided the real exchange be at par, and that the currency of both cities is at the mint standard, that the *nominal*, or, which in this case is the same thing, the *computed* exchange, will be five per cent. in favour of London. But if the currency of London be five per cent. depreciated, or, in other words, if the market price of bullion at London be five per cent. above its mint price, the *computed* exchange between it and Rio Janeiro, supposing the *real* exchange to continue at par, will obviously also be at par. It may therefore be laid down as a general rule, that as soon as bullion begins to pass from one country to another, *the expense of transit*, provided the mint and market price of bullion in the *exporting* country correspond, will indicate how much the value of bullion in it falls short of its value in the country into which it is imported; or, which is the same thing, will be equal to its unfavourable *nominal* exchange; and that, when the market exceeds the mint price of bullion in the *exporting* country, the expense of transit *added* to this excess will give the total comparative reduction of the value of the precious metals in that country. The converse of this takes place in the country *importing* bullion. When its currency is of the mint standard, the expense of transit measures the extent of its favourable *nominal* exchange; but when its currency is relatively redundant or degraded, the *difference* between the expense of transit and the excess of the market above the mint price of bullion, will measure the extent of the favourable or unfavourable *nominal* exchange. It will be favourable when the depreciation is less than the expense of transit, and unfavourable when it is greater.

From 1809 to 1815 inclusive, Great Britain continued to export gold and silver to the Continent. During this period, therefore, we must add the expenses attending its transit to the excess of the market over the mint price of bullion, in order to ascertain the true relative value of British currency, and the state of the *real* exchange. Mr Goldsmid stated to the bullion committee that, during the last five or six months of the year 1809, the expense of transporting gold to Holland and Hamburg, inclusive of freight, insurance, exporter's profits, &c. varied from four to seven per cent. But at the same time that the relative value of bullion in Britain was at five and a half (medium of four and seven) per cent. below its value in Hamburg, the market price of gold bullion exceeded its mint price to the extent or sixteen or twenty per cent. or eighteen per cent. on a medium; so that the currency of this country, as compared with the currency of Hamburg, which differed very little from its mint standard, was really depreciated to the extent of twenty-three and a half per cent. Now, as the *computed* or actual course of exchange varied, during the same period, from nineteen to twenty-one per cent. against London, it is clear that the *real* exchange could not be very different from par. Had the *computed* exchange been less unfavourable, it would have shown that the *real* exchange was in favour of London; had it been more unfavourable, it would, on the contrary, have shown that the *real* exchange was decidedly against London.

Provided an accurate account could be obtained of the expense attending the transit of bullion from this country to the Continent during the subsequent years of the war, we have no doubt it would be found, notwithstanding the extraordinary depression of the *nominal*, that the *real* exchange fluctuated very little from par; and that the exportation of gold and silver was a consequence, not of the balance of payments being against this country, but of its being advantageous to export bullion, because of its being less valuable here than on the Continent. No person will contend that, in 1809, 1810, &c. there was such a redundancy of gold or silver currency in this country as to sink the relative value of these metals. Any such supposition is altogether out of the question. During the period referred to, the precious metals were sent out of the country, because the depreciation of the paper currency exceeded the cost of the transit of bullion; and hence, because it was every body's interest to pay their debts in the depreciated currency, and to export that which was undepreciated to other countries where there was no law to prevent its passing at its full value as coin, or in which there was a greater demand for bullion. It is indisputably certain that, if our *paper currency* had been sufficiently reduced, the supply of gold in the kingdom in 1809, 1810, &c. compared with the demand which must, under such circumstances, have been experienced, was so very small, that, instead of exporting, we should have imported the precious metals from every country in the world.

It has been very generally supposed, that the extraordinary exportation of British goods to the Continent during the latter years of the war, was in a great measure owing to the depression of the exchange. But, in so far as this depression was occasioned by the redundancy or depreciation of the currency, it could have no such effect. It is impossible, indeed, to form any opinion as to the influence of fluctuations in the *computed* exchange on export and import trade, without previously ascertaining whether they are a consequence of fluctuations in the *real* or *nominal* exchange. It is only by an unfavourable *real* exchange that exportation is facilitated; and it may be favourable at the very moment that the *computed* exchange is decidedly unfavourable. "Suppose," to use an example given by Mr Blake, "the computed exchange between Hamburg and London to be one per cent. against this country, and that this arises from a *real* exchange which is favourable to the amount of four per cent. and a nominal exchange unfavourable to the extent of five per cent.; let the real price of bullion at Hamburg and London be precisely the same, and, consequently, the *nominal* prices different by the amount of the *nominal* exchange or five per cent; now if the expenses of freight, insurance, &c. on the transit of bullion from Hamburg are three per cent., it is evident that a profit would be derived from the import of that article, notwithstanding the *computed* exchange was one per cent. against us. In this case the merchant must give a premium of one per cent. for the foreign bill, to pay for the bullion: L.100 worth of bullion at Hamburg would therefore cost him L.101, and the charges of importation would increase the sum to L.104. Upon the subsequent sale, then, for L.105 of depreciated currency in the home market, he would derive from the transaction a profit of L.1. This sum is precisely the difference between the *real* exchange and the expenses of transit, that part of the *computed* exchange which depends on the *nominal* producing no effect; since whatever is lost by its unfavourable state is counterbalanced by a corresponding inequality of *nominal* prices." (*Observations*, &c. p. 91.) In the same manner it may be shown, that, though the *computed* be favourable, the *real* exchange may be unfavourable; and that, consequently, it might be really advantageous to export, when it was apparently advantageous to import. But it would be tedious to multiply instances, which, as the intelligent reader will readily conceive, may be infinitely varied, and which have been sufficiently explained in the foregoing sections.

The real cause of the extraordinary importation of British produce into the Continent in 1809, 1810, &c. notwithstanding the anticommercial system of Napoleon, is to be found, not in the state of the exchange; for, inasmuch as that was occasioned by a fall in the value of the currency, it could have no effect whatever either in increasing or diminishing exportation; but in the annihilation of the neutral trade, and our monopoly of the commerce of the world. The entire produce of the East and of the West was placed at our disposal. The continental nations could neither procure colonial produce nor raw cotton for the purposes of manufacturing, except directly from England. British merchandise was thus rendered almost indispensable; and to this our immense exportation, in spite of all prohibitions to the contrary, is to be ascribed. (See *Edinburgh Review*, No. lxiii. p. 50.)

Negotiation of Bills of Exchange.

In conducting the business of exchange, a direct remittance is not always preferred. When a merchant in London, for example, means to discharge a debt due by him in Paris, it is his business to ascertain not only the state of the direct exchange between London and Paris, and, consequently, the sum which he must pay in London for a bill on Paris equivalent to his debt, but also the state of the exchange between London and Hamburg, Hamburg and Paris, &c.; for it frequently happens, that it will be more advantageous for him to buy a bill on Hamburg, Amsterdam, or Lisbon, and to direct his agent to invest the proceeds in a bill on Paris, rather than remit directly to the latter. This is termed the ARBITRATION of exchange. An example or two will suffice to show the principle on which it is conducted.

Thus, if the exchange between London and Amsterdam be 35s. Flemish per pound sterling, and between Paris and Amsterdam 1s. 6d. Flemish per franc, then, in order to ascertain whether a direct or indirect remittance to Paris would be most advantageous, we must calculate what would be the value of the franc in English money if the remittance were made through Holland; for if it be less than that resulting from the direct exchange, it will obviously be the preferable mode of remitting. This is determined by stating, as 35s. Flem. (the Amsterdam currency in a pound sterling): 1s. 6d. Flem. (Amsterdam currency in a franc) : : L.1. : 10d. the proportional or *arbitrated* value of the franc. Hence if the English money or bill of exchange, to pay a debt in Paris, were remitted by Amsterdam, it would require 10d. to discharge a debt of a franc, or L.1 to discharge a debt of 24 francs: and, therefore, if the exchange between London and Paris were at twenty-four, it would be indifferent to the English merchant whether he remitted directly to Paris, or indirectly *via* Amsterdam; but if the exchange between London and Paris were *above* twenty-four, then a direct remittance would be preferable; while, if, on the other hand, the direct exchange were less than twenty-four, the indirect remittance ought as plainly to be preferred.

Negotiation of Bills of Exchange.

"Suppose," to borrow an example from Dr Kelly (*Universal Cambist*, vol. ii. p. 137), "the exchange of London and Lisbon to be at 68d. per milree, and that of Lisbon on Madrid 500 rees per dollar, the arbitrated price between London and Madrid is 34d. sterling per dollar; for as 1000 rees : 68d. : : 500 rees : 34d. But if the direct exchange of London on Madrid be 35d. sterling per dollar, then London, by remitting directly to Madrid, must pay 35d. for every dollar; whereas, by remitting through Lisbon, he will pay only 34d.; it is, therefore, the interest of London to remit indirectly to Madrid through Lisbon. On the other hand, if London draws directly on Madrid, he will receive 35d. sterling per dollar; whereas, by drawing indirectly through Lisbon, he would receive only 34d.; it is, therefore, the interest of London to draw directly on Madrid. Hence the following rules:

"1. Where the *certain price* is given, draw through the place which produces the lowest arbitrated price, and remit through that which produces the highest.

"2. Where the *uncertain price* is given, draw through that place which produces the highest arbitrated price, and remit through that which produces the lowest."

In COMPOUND ARBITRATION, or when more than *three* places are concerned, then, in order to find how much a remittance passing through them all will amount to in the last place, or, which is the same thing, to find the arbitrated price between the first and the last, we have only to repeat the different statements, in the same manner as in the foregoing examples.

Thus, if the exchange between London and Amsterdam be 35s. Flem. for L.1 sterling; between Amsterdam and Lisbon 42d. Flem. for 1 old crusade; and between Lisbon and Paris 480 rees for 3 francs, What is the arbitrated price between London and Paris?

In the first place, as 35s. Flem. : L.1 : : 42d. Flem. : 2s. sterling, = 1 old crusade.

Second, as 1 old crusade, or 400 rees : 2s. sterling : : 480 rees : 2s. $4\frac{4}{5}$d. sterling, = 3 francs.

Third, as 2s. $4\frac{4}{5}$. sterling : 3 francs : : L.1 sterling : 25 francs, the arbitrated price of the pound sterling between London and Paris.

This operation may be abridged as follows:

		L.1 sterling.
L.1 sterling	=	35s. Flemish.
$3\frac{1}{2}$ shillings Flem.	=	1 old crusade.
1 old crusade	=	400 rees.
480 rees	=	3 francs.

$$\text{Hence } \frac{35 \times 400 \times 3}{480 \times 3\frac{1}{2}} = \frac{4200}{168} = 25 \text{ francs.}$$

This abridged operation evidently consists in arranging the terms so that those which would form the divisors in continued statements in the *Rule of Three* are multiplied

Negotiation of Bills of Exchange.

together for a common divisor, and the other terms for a common dividend. Arithmetical books abound with examples of such operations.

The following account of the manner in which a very large transaction was actually conducted, by indirect remittances, will sufficiently illustrate the principles we have been endeavouring to explain.

In 1804 Spain was bound to pay to France a large subsidy; and, in order to do this, three distinct methods presented themselves;

1. To send dollars to Paris by land.
2. To remit bills of exchange directly to Paris.
3. To authorise Paris to draw directly on Spain.

The first of these methods was tried, but it was found too slow and expensive; and the second and third plans were considered likely to turn the exchange against Spain. The following method by the indirect or circular exchange was therefore adopted.

A merchant, or *banquier*, at Paris, was appointed to manage the operation, which he thus conducted: He chose London, Amsterdam, Hamburg, Cadiz, Madrid, and Paris, as the principal hinges on which the operation was to turn; and he engaged correspondents in each of these cities to support the circulation. Madrid and Cadiz were the places in Spain from whence remittances were to be made; and dollars were, of course, to be sent to where they bore the highest price, for which bills were to be procured on Paris, or on any other places that might be deemed more advantageous.

The principle being thus established, it only remained to regulate the extent of the operation, so as not to issue too much paper on Spain, and to give the circulation as much support as possible from real business. With this view London was chosen as a place to which the operation might be chiefly directed, as the price of dollars was then high in England, a circumstance which rendered the proportional exchange advantageous to Spain.

The business was commenced at Paris, where the negotiation of drafts issued on Hamburg and Amsterdam served to answer the immediate demands of the state; and orders were transmitted to these places to draw for the reimbursements on London, Madrid, or Cadiz, according as the course of exchange was most favourable. The proceedings were all conducted with judgment, and attended with complete success. At the commencement of the operation, the course of exchange of Cadiz on London was 36d.; but, by the plan adopted, Spain got 39¼d. or above eight per cent. by the remittance of dollars to London, and considerable advantages were also gained by the circulation of bills through the several places on the Continent.[1]

Usance days of grace.

Bills of exchange are made payable at *sight*;—at a certain specified time *after sight*, or *after date*;—or at *usance*, which is the usual term allowed by the custom or law of the place where the bill is payable. Generally, however, a few days are allowed for payment beyond the term when the bill becomes due, which are denominated *days of grace*, and which vary in different countries. In Great Britain and Ireland *three* days of grace are allowed for all bills except those payable at sight, which must be paid as soon as presented.

The following is a statement of the *usance* and *days of grace* for bills drawn by London on some of the principal commercial cities:

[*m*|*d*. *m*|*s*. *d*|*d*. *d*|*s*. *d*|*a*. respectively denote *months after date*, *months after sight*, *days after date*, *days after sight*, *days after acceptance*.]

London on	Usance.	Days of Grace.	London on	Usance.	Days of Grace.
Amsterdam	1 m|d.	6	Gibraltar...	2 m|s.	14
Rotterdam.	1 m|d.	6	Leghorn....	3 m|d.	0
Antwerp...	1 m|d.	6	Leipsic......	14 d|a.	0
Hamburg...	1 m|d.	12	Genoa......	3 m|d.	30
Altona......	1 m|d.	12	Venice.......	3 m|d.	6
Dantzic.....	14 d|a.	10	Vienna[3].....	14 d|a.	3
Paris[2].......	30 d|d.	10	Malta.......	30 d|d.	13
Bordeaux...	30 d|d.	10	Naples......	3 m|d.	3
Bremen.....	1 m|d.	8	Palermo....	3 m|d.	0
Barcelona...	60 d|d.	14	Lisbon......	30 d|s.	6
Geneva......	30 d|d.	5	Oporto.......	30 d|s.	6
Madrid......	2 m|s.	14	Rio Janeiro	30 d|d.	6
Cadiz........	60 d|d.	6	Dublin......	21 d|s.	3
Bilboa.......	2 m|d.	14	Cork.........	21 d|s.	3

In the dating of bills the new style is now used in every country in Europe with the exception of Russia.

In London, bills of exchange are bought and sold by brokers, who go round to the principal merchants, and discover whether they are buyers or sellers of bills. A few of the brokers of most influence, after ascertaining the state of the supply and demand for bills, suggest a price at which the greater part of the transactions of the day are settled, with such deviations as particular bills, from their being in very high or low credit, may be subject to. The price fixed by the brokers is that which is published in Wettenhall's list; but it is stated by Mr Goldsmid, that the first houses generally negotiate their bills on a half, one, one and a half, and two per cent. better terms than those quoted. In London and other great commercial cities, a class of middlemen speculate largely on the rise and fall of the exchange, buying bills when they expect a rise, and selling them when a fall is anticipated.

History and Advantages of Bills of Exchange.

It is not easy to discover the precise era when bills of exchange were first employed to transfer and adjust the mutual claims and obligations of merchants. Their invention has been ascribed to the Arabians and the Jews of the middle ages; but it seems certain that bills were in use in remote antiquity. Isocrates states that a stranger who brought some cargoes of corn to Athens, furnished a merchant of the name of Stratocles with an order or bill of exchange, on a town on the Pontus Euxinus, where money was owing to him; and, because the person who had drawn the bill had no *fixed domicile*, Stratocles was to have recourse on a merchant in Athens, in the event of its being protested. The merchant, says Isocrates, who procured this order found it extremely advantageous, inasmuch as it enabled him to avoid risking his fortune on seas covered with pirates and the hostile squadrons of the Lacedæmonians. (De Pauw, *Recherches sur les Grècs*, i. 258.)

There is also unquestionable evidence to show that the method of transferring and cancelling the debts of parties

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[1] Kelly's *Cambist*, vol. ii. p. 168; Dubost's *Elements of Commerce*, 2d edit. p. 218.

[2] In France no days of grace are allowed on bills payable *à vue*.

[3] In Austria, bills payable at sight, or on demand, or at less than seven days after sight or date, are not allowed any days of grace.

History of Bills of Exchange.

residing at a distance, by means of letters of credit, or, which is in effect the same thing, by means of bills of exchange, was not unknown to the Romans. Cicero, in one of his epistles to Atticus (*Epist. ad Atticum*, xii. 24), inquires whether his son must carry cash to defray the expense of his studies along with him to Athens, or whether he might not save this trouble and expense *by obtaining an assignment for an equivalent sum from a creditor in Rome on his debtor there.* It is evident, from a subsequent epistle of Cicero's, that the latter method had been preferred, and that the transference of the money had in consequence been rendered unnecessary. (*Epist. ad Atticum*, xii. 27.)[1]

Mr Macpherson states (*Annals of Commerce*, i. p. 405), that the first mention of bills of exchange in modern history occurs in 1255. The pope having quarrelled with Manfred, king of Sicily, engaged, on Henry III. of England agreeing to indemnify him for the expense, to depose Manfred, and raise his second son Edmund to the Sicilian throne. The enterprise misgave. But the merchants of Sienna and Florence who originally advanced the money to carry it into effect, or rather to gratify the pope's rapacity, were paid by bills of exchange drawn on the *Prelates* of England, who, although they protested they knew nothing at all about the transaction, were nevertheless compelled, under pain of excommunication, to pay the bills and *interest!*

Capmany, in his *Memoirs* respecting the Commerce, &c. of Barcelona, gives a copy of an ordonnance of the magistracy, dated in 1394, enacting that bills should be accepted within twenty-four hours after their presentation;—a sufficient proof that they were in general use in the beginning of the fourteenth century.

But whatever be the era of the introduction of bills of exchange, very few inventions have redounded more to the general advantage. Without this simple and ingenious contrivance, commerce could not have made any considerable progress. Had there been no means of settling and adjusting the mutual claims of debtors and creditors otherwise than by the intervention of metallic money (for bank paper is only another species of bills of exchange), a very great proportion,—many hundreds of millions,—of that capital which is now setting productive labour in motion in every quarter of the globe, and ministering to the wants and the enjoyments of mankind, must have been devoted to the expediting those exchanges which are much better accomplished by the agency of a few quires of paper. Instead of a perpetual importation and exportation of gold and silver, necessarily attended by an immensity of trouble and expense, a few bills of exchange, possessing little or no intrinsic worth, and which may be transferred with the utmost facility, suffice to adjust the most extensive and complicated transactions. But the mere setting free of an immense productive power, engaged in a comparatively disadvantageous employment, is only one of the many benefits we owe to the use of bills of exchange. By cheapening the instruments by which commerce is carried on, they have materially reduced the prices of most commodities; and have, in consequence, increased the command of all classes over the necessaries and luxuries of life, and accelerated the progress of civilization, by occasioning a much more extensive intercourse and intimate connection between different and independent countries, than could otherwise have taken place.

In a political point of view their effects have been equally salutary. They enable every individual imperceptibly to transfer his fortune to other countries, and to preserve it safe alike from the rapacity of his own government and the hostile attacks of others. The security of property has, in consequence, been prodigiously augmented. And though we should concede to the satirist that paper credit has "lent corruption lighter wings to fly,"[2] it is easy to show that it has powerfully contributed to render subjects less dependent on the policy, and less liable to be injuriously affected by injudicious measures on the part of their rulers. In countries in a low stage of civilization, the inhabitants endeavour, by burying all the gold and silver they can collect, to preserve a part of their property from the despots by whom they are alternately plundered and oppressed. This was universally the case in the middle ages; and in Turkey, India, Persia, and other eastern countries, the practice is still carried on to a very great extent. Some economists have endeavoured to account for the long-continued importation and high value of the precious metals in India, by the loss which necessarily attends the practice of hoarding; and undoubtedly this locking up of capital is one of the main causes of the extreme poverty of these countries. But the security afforded by bills of exchange is infinitely greater than any derived from the barbarous expedient of trusting property to the bosom of the earth. "Pregnant with thousands flits the *scrap* unseen," and in a moment places the largest fortune beyond the reach of danger! Mr Harris was, therefore, right in saying, "that the introduction of bills of exchange was the greatest security to merchants, both as to their persons and effects, and consequently the greatest encouragement to commerce, and the greatest blow to despotism, of any thing that ever was invented." (Harris *on Coins*, part i. p. 108.)

Previously to the peace of Paris in 1763, Amsterdam, because of its commerce, the wealth and punctuality of its merchants, and their intimate connection with all the other great trading cities of the world, was the chief place where the accounts of the different commercial countries were balanced and adjusted. But the entire loss of foreign trade, and the other vexations to which Holland was subjected during the ascendancy of the French, nearly divested Amsterdam of all share in this business. London has now become the trading metropolis of Europe, and of the world. The vast extent of its commercial dealings has necessarily rendered it the great mart for bills of exchange. Its bill merchants, a class of men remarkable for their shrewdness, and generally possessed of large capitals, assist in trimming and adjusting the balance of debt and credit between the most remote countries. They buy up bills where they are cheap, and sell them where they are dear; and, by the extent of their correspondence and the magnitude of their transactions, give a steadiness to the exchange, which it could not otherwise attain.

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[1] "De Cicerone, ut scribis, ita faciam: ipsi permittam de tempore: nummorum quantum opus erit ut *permutetur* tu videbis." In his notes on a parallel passage, Grævius remarks, *Permutatio* est quod nunc barbare *cambium* dicitur. (*Epist. ad Atticum*, xi. 24.)

[2] Blest paper credit! last and best supply!
That lends corruption lighter wings to fly!
Gold imp'd by thee can compass hardest things,
Can pocket states, can fetch or carry kings;
A single leaf shall waft an army o'er,
Or ship of senates, to some distant shore;
A leaf, like Sibyll's, scatter to and fro
Our fates and fortunes, as the wind shall blow;
Pregnant with thousands flits the scrap unseen,
And silent sells a king, or buys a queen.—POPE.

Laws and Customs Respecting Bills and Notes.

Law respecting bills, &c.

A bill of exchange may be defined to be an open letter of request or order from one person, the *drawer*, to another person, the *drawee*, who is thereby desired to pay a sum of money, therein specified, to a third person, the *payee*. When the *drawee* obeys the request or order, by subscribing the document, he becomes *acceptor*. If the contrary do not appear on the face of the bill, it is presumed that the *drawee* has funds of the *drawer's* in his hands to the amount of the bill, and that the drawer is indebted to the *payee* to that extent. The bill thus operates as a transfer or mercantile assignment to the payee, of the drawee's debt to the drawer. But a bill may also be drawn payable to the *drawer* or his order, in which case, when accepted, the document is not an assignment, but merely the acknowledgment or constitution of a debt. This is also accomplishable by *promissory note*, which is a promise by one person, the *maker* (Scoticé *granter*), to pay a sum to another person, the *payee* (Scoticé *grantee*). The bill and the promissory note have now equally the privilege of being *assignable* or *transferable* from one person to another by indorsement, that is, by the *payee* subscribing his name on the back of the document. In this case the *payee* becomes an *indorser*, and the person in whose favour the indorsement is made is called the *indorsee*, who may again indorse to another; and in this manner the bill or note may pass from hand to hand without limitation. Each indorsation may be made *in full* or *in blank;* in full, by filling up the name and description of the party in whose favour it is made, which is attended with several advantages if the document should be lost or stolen; in blank, by merely subscribing the indorser's name, which is equivalent to making it payable to the *bearer*. All the indorsements, or any one of them, may also be *qualified* by the words *without recourse;* and when this is done, neither the indorsee nor any subsequent *holder* of the bill or note can have recourse on the indorser who thus qualifies his indorsation. If none of the indorsations be so qualified, the *last holder* for value, and *in bona fide*, has all the prior indorsers and other parties to the bill or note bound to him jointly and severally. He may select any one of them, or proceed against them all at the same time; and if all were to become bankrupt, he could claim on the estate of each for the whole debt, and be entitled to receive dividends from all the estates until he obtained *full payment*, but which he must not exceed. An indorser may also qualify his indorsation by the condition that his indorsee shall not have the power of making an indorsement from himself.

From the negotiability thus conferred upon them, bills have been compared to bags of money; but it should be remembered that, in the former case, we transfer only *a right*, in the latter the *property itself*. The comparison is best supported in those transferences which are made without recourse, since, in those instances, the bill passes from hand to hand without any alteration in the rights and duties of those interested in it, and without any one acquiring an additional security. In the simplest case, however, the rights arising on a bill may be preserved or lost by the conduct of the holder; and where there has been even one unqualified indorsation, the duties of the holder are of a delicate and important nature. But these will be more readily understood after we have pointed out the requisites of a bill.

The general requisites of a bill are, that it must be payable at all events; that it must be for payment of money only; and that the money must not be payable from any particular fund. Of the more special requisites, the *first* is, that any bill or note drawn or made in Great Britain (though dated abroad[1]) or in its colonies, is, that it be written on paper *stamped* according to the law of the mother country or colony, as it happens to be drawn in the one or the other. The stamp-duty varies according to the sum in the bill, and the extension of the term of payment: but for these particulars, and the mode of complying with the provisions of the law, reference should be made to the statutes in force at the time. The present regulating statute is that of 55 Geo. III. c. 184, both as to *inland* bills and notes, and bills of exchange drawn here *on* foreign countries. As to bills truly drawn in foreign states, not colonies of Great Britain, on traders in this country, our law takes no cognizance of them as to whether they are or are not stamped; but *promissory notes* made *out* of Britain are declared *not* to be negotiable or payable unless stamped agreeably to our laws. Bills drawn at home must also be written on the stamp appropriated for bills. If on a stamp of another denomination, though of equal or superior value, they are invalid if not got re-stamped, which they may be for payment of the duty and a penalty of 40s. when carried to the stamp-office before they are due, but when after due, the penalty is L.10. If written on a stamp below the proper value, a penalty is incurred of L.50, and the bills, besides, are *null* (Bell's *Com. on Bankrupt Law*, vol. ii. p. 249); but it has been found with us in England, that if a bill be *not* properly stamped, a neglect to present for acceptance or payment will not relieve parties who are *otherwise* liable in the *original debt* in respect of which the bill was granted. The relief in this case is granted by a court of equity, but this relief is not extended to remote indorsers not responsible for the original debt. Relief, however, is given when a party has bound himself to grant a valid note or bill, but gives one by mistake or design on a defective stamp. Negotiable bills under L.5 must, by 37 Geo. III. c. 32, be payable within twenty-one days, and bear the name of the *place* where they are made, without which also *checks* on bankers are liable to stamp-duty. Penalties are likewise imposed on the post-dating of such *checks*, or of bills, for the purpose of reducing the duty by apparently shortening the term of payment; and there are provisions in those laws respecting bills drawn in sets or otherwise, with which every trader should make himself acquainted. This, however, it is very difficult to do in all its bearings, since the penalties and provisions of the prior statutes are retained in every subsequent one, except as therein specially altered. This is one great evil in our fiscal regulations. Where the law cannot be known, transactions are rendered uncertain, property insecure, and litigation is increased to a mischievous extent. But the worst evil is, that this state of the law increases in a prodigious degree the influence of the crown, by the power over traders which is thus placed in the hands of solicitors of stamps, excise, customs, and other crown officers.

The other requisites of a bill are, *2dly*, That it should bear the name of the place at which it is made or drawn; and if the street and number of the house be added, it is

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[1] Chitty, 5th edit. p. 70, 7 T. R. 601, 4 Camp. *Law*, 269.

Laws of Bills of Exchange.

easier to give and receive the notices that may be necessary, in proper time. 3*dly*, The *date* should be distinctly marked, and, if *written* at length, a higher protection would be afforded against accidental or intentional alterations and vitiations. If a bill have no date, the date of issuing will be held as the date of the bill. 4*thly*, The time of payment should be clearly expressed, and a *time certain* is necessary to make the document *negotiable*; that is to say, the payment must not depend on an event that may never happen, such as the *marriage of a person*, though it may on the *death*. 5*thly*, The *place* at which a bill is made payable should also, for the sake of safe negotiation, be distinctly stated; because at that place *presentment* must be made both for acceptance and payment. If no place be mentioned, the place of doing business, if the acceptor have one, or otherwise his dwelling-house, becomes the place of presentment. 6*thly*, The sum payable should be clearly written in the body of the bill, and the superscription of the sum in figures will aid an omission in the body. This sum must in all cases be above 20s.; and if payable more than twenty-one days after date, it must exceed L.5. 7*thly*, It should contain an order or request to pay. 8*thly*, Of bills drawn in parts or sets, each part or copy should mention the number of copies used, and be made payable on condition that none of the others has been paid. The *forgery* of an indorsement on one of the parts passes no interest even to a *bona fide* holder, and will not prevent the payee from recovering on the other part. 9*thly*, Every bill should specify distinctly *to whom* the contents are to be paid; but a *bona fide* holder, or his executor, may fill up a blank, if one be left, for the name of the payee, and recover payment. (Chitty, 82; Bell, vol. ii. p. 251, &c.) 10*thly*, If it be intended that a bill is to be negotiable, it should contain the operative words of transfer "to order;" although, if the original intention be clear, these words may be inserted without a fresh stamp. (Chitty, 86.) 11*thly*, It is advisable in all cases to insert *value received*; since, without these words, the holder of an *inland* bill for upwards of L.20 could not, in England, recover interest and damages against the drawer and indorser in default of acceptance or payment. Bills bearing for value received, and payable *after date*, seem also to possess advantages when lost, under the statutes 9 and 10 W. III. c. 17; but equity would probably extend these to indorsements; and 3 and 4 Anne, c. 9, it is thought, extends the same to notes. (Chitty, p. 196.) 12*thly*, As to foreign bills, the drawee should attend to whether they are to be paid *with* or *without further advice*; since the propriety of his accepting or paying will, in the one case, depend on his having received advice. The more carefully all these requisites are attended to, the greater is the security of all concerned against accidents and litigation. But traders, we fear, have too generally a prejudice in favour of that brevity which approaches to looseness of expression, and against that precision which alone can keep them out of difficulties.

Ge l expl a- tor les and ges.

When a bill, check, or note, is payable *on demand*, or when *no time of payment is expressed*, it should be presented within a reasonable time after receipt, and is payable *on presentment*, without the allowance of any days of grace. It is yet *unsettled* (Chitty, 344, *et seq.*) whether bills drawn *at sight* are entitled to days of grace, though the weight of authority is rather in favour of them. If drawn at one or more days after sight, the days of grace must be allowed. The day on which a bill is dated is not reckoned one; but all bills having days of grace, become due, and must be presented and protested, *on the third day*, and if that day be a Sunday or holiday, on *the second*. The rule for giving notice of non-acceptance or non-payment is different, since, if the day on which it should have been given be a day of rest, by the religion of the party, such as the Jews' Sabbath, the notices will be good if given on the next day. Calendar months are always understood with respect to bills; and if dated on the 29th, 30th, or 31st of January, payable *one month* after date, they will fall due on the *last day* of February, from which the days of grace are to be calculated. Presentments of bills should be made within business hours. These are generally considered to be in London from nine morning to six evening, but a protest has been held good against an ordinary trader when made at eight. This would not have been good in the case of bankers, whose hours (from nine to five in London) must be attended to. In Edinburgh, bankers' hours are from ten to three; traders from ten to three and from six to eight; but there are no Scotch decisions holding these as the only business hours. A verbal notice of the dishonour of an *inland* bill is good; but as such notice is always matter of parole evidence, it is better in every case to give notice in writing, and the regular mode of doing so is by post. Such notice, if put into the general post-office, or an authorized receiving-house, is good though it miscarry, provided the letter be regularly booked, and reasonable proof be made of its having been put into the post-office. If given only to a bellman in the street, it would not in such a case be good. When there is no post, the ordinary mode of conveyance, such as the *first* ship or carrier, is sufficient. As to *foreign bills*, notices of dishonour, with the respective protests, must be dispatched by post on the day when the bills become due, or on which the acceptance was refused, if any post or ordinary conveyance set out that day, and if not, by the next earliest conveyance. (Chitty, 291.) As to *inland* bills, notice should be made by the first post after the expiry of a day, when the parties reside at a distance; if in the same town it is enough if the notice be made so as to be received within business hours of the following day, and this may be done by the twopenny or penny post, if receivable within the time mentioned. When a holder deposits his bill at his banker's, the number of persons entitled to notice is increased by one; and each party in succession is entitled to *twenty-four hours* for giving notice (6 East. 3 Bell, 263.) Such notice, as to inland bills, is necessary in England for preserving recourse as to the principal sum only. If protest be made and notice given within fourteen days, the recourse is preserved as to *interest*, damages, and expenses. In Scotland a protest is necessary in every case, and there is no distinction made as to the mode of recourse between principal and interest; but intimation to the drawer within *fourteen* days preserves recourse for the whole (Bell, vol. ii. p. 265); and it has been decided, that notice of an indorser may be good even after the fourteen days, if there has been no unnecessary delay. (*Fac. Col.* 2d June 1812.) But this applies only to *inland* bills, and a bill drawn from Scotland upon England is in Scotland held to be foreign. (Bell, vol. ii. p. 265.) Every bill should be presented for payment on the day upon which it falls due, unless that be rendered impossible by some unforeseen and *inevitable* accident, such as shipwreck, or sudden illness, or death. To preserve recourse, the accident, and the presentment of the bill as soon as possible afterwards, must be intimated without delay, and, if denied, proved by the party who seeks recourse. The same doctrine will hold as to presentments for non-acceptance and notices of dishonour. But the loss or destruction of a bill is no excuse for not demanding payment and protesting; the protest in that case being made upon a copy or statement of the bill, if the party who has right to hold the bill has it in his power to make such a statement. If the destruction of the bill can be proved, action will be sus-

Business hours.

Rules of giving notices.

Effect of inevitable accident.

How to act when bill lost.

tained in a court of law; if not, the redress is got upon giving an indemnity in a court of equity; but as equity will not interfere where law can, it is of importance in such a case, and indeed in all cases of difficulty, to resort at once to the best professional advice. Inconsiderate attempts to remedy neglects, or cure what is defective, generally make the case worse, and often implicate character.

Effect of usury.

Cases of great hardship and difficulty frequently arose on bills granted partly for *usurious* consideration. A mighty benefit, however, has now been conferred by the statute 58 Geo. III. c. 93, which enacts, "That *no bill* of exchange or promissory note that shall be drawn or made after the passing of this act shall, though it may have been given for a usurious consideration, or upon a usurious contract, *be void* in *the hands of an indorsee for valuable consideration*, unless such an indorsee had, at the time of discounting or paying such consideration for the same, *actual notice* that such bill, &c. had been originally given for a usurious consideration, or upon a usurious contract."

Effect of gaming.

It is much to be regretted that the same protection was not extended by this statute to the *innocent holder* of a bill granted for a game debt. Such bills are still void in the hands of a *bona fide* indorsee. In Scotland it has been decided otherwise. (25th January 1740, Nielson; Bell, vol. ii. p. 210.) The rage for legislation has not yet extended itself to lawyers, who, as a body, can hardly be expected to display an anxiety to remedy defects which add to their emoluments and consequence. How much of the learning of this profession is wasted on niceties and difficulties that would readily yield to the spell of an act of parliament! To the law, however, we owe this sound maxim, that "unless it has been so expressly declared by the legislature, as it formerly was in the case of usury, and still is as to bills for *game* debts, illegality of consideration will be no defence in an action at the suit of a *bona fide* holder, without notice of the illegality, unless he obtained the bill after it became due." (Chitty, 105.)

Effect of forgery.

Thus *forgery* does not vitiate a bill. The forged document is good to and against all parties but those whose names are forged. Against one whose name is forged, it is true, it will neither support an action nor ground a claim; "yet if he have given credit to acceptances or indorsations as binding on him, forged by the same hand, he will be liable." (3 Esp. N. P. 60; 2 Bell, 250.) Subsequent approbation also does away an objection on the head of forgery or fraud, and generally all sorts of objections otherwise competent.

Effect of vitiation.

This doctrine holds as to vitiations when the stamp laws are not concerned; but without the consent of parties all vitiations or alterations of bills in material parts are fatal. (2 Bell, 252.)

Acceptance by procuration.

A clerk or servant may accept a bill for his master if authorized so to do; and authority will be inferred from a sanctioned practice. The law on this point is dangerous, and would require legislative revision. If the servant or agent do not explain the character in which he acts, but subscribes his own name simply, he will bind himself, not his employer.

Conditional acceptance.

An acceptor may enlarge the term of payment, or accept for a part, or under any other condition not expressed in the bill; but in that case it is optional in the holder to take the acceptance as thus offered, or to proceed as if no such offer had been made; if rejected, the protest should bear the condition, and the rejection of it; it should also be kept in view, that a *holder* who accepts of a limited or conditional acceptance, liberates the drawer and prior indorser, unless he have their consent.

Indorsements.

Blank indorsements are held to be of the date of the bill, until the contrary is proved. Indorsements after the term of payment, though for value, do not protect the indorsees like indorsements before maturity; very slight evidence is admitted as proof of knowledge of dishonour, and the holder in that case becomes liable to all exceptions which can be stated against the right of his immediate indorser, or the person who held the bill when it became due. When acceptance is refused, and the bill returned with protest, action may be raised immediately against the drawer, though the regular time of payment is not arrived. His debt, in such a case, is considered as contracted the moment the bill was drawn; if the date of the bill be prior to that of a commission of bankrupt, the debt, in such a case, may be claimed upon. As to current bills and contingent claims, the case is unfortunately different; in these respects England might derive great help from the law of Scotland.

The *drawee*, who, having funds, refuses to accept, is responsible for the consequences to the *drawer*, and may also be sued for payment by the payee or holder, the presentment and protesting of the bill for non-acceptance operating as an intimated assignment and complete transfer of the debt *to the holder*, who in Scotland is preferred to any subsequent arrester. The *drawee* who has no funds is not bound to accept; but, after protest for non-acceptance, he may accept supra-protest, for the *honour* of the drawer and indorsers, or either of them. A *third party* may thus accept for *honour* supra-protest; and whoever does so, if he give immediate notice, and send off the protest, may have immediate recourse on the party or parties for whose honour he has interfered.

It is the duty of a *payee*, when directed by the drawer, and of every one who is merely an agent for the owner, though acting gratuitously, to present a bill for acceptance. The time thought reasonable for this purpose is twenty-four hours, or at least within business hours of the day following that on which the bill was received. It is prudent in all holders of a bill to present for acceptance within this period; and *in all cases* where a presentment is made, and acceptance refused, notice should be given to all against whom it is meant to preserve recourse. A draught may be left twenty-four hours with the drawee, if no post go out in the mean time; but if he intimate within that time that he will not accept, or ask *more time* to consider, *notice should be given.* (Chitty, 288, 289.) A verbal acceptance, if it can be proved, or one by a separate writing, binds the drawee; but in Scotland none but a written acceptance on the bill will authorize the usual summary diligence. (Chitty, 217–270; 2 Bell, 69–240.) If the drawee had no funds, notice to the drawer is not necessary; but as the not having funds is a matter of fact to be proved, it is safer in this, and indeed in all other cases, to give the usual and regular notice. When a bill is drawn at some certain time *after sight*, presentment is *necessary* to fix the term of payment. Respecting bills of this description, both foreign and inland, the general rule is, that *due diligence must be used.* Foreign bills, so drawn, may be put into the circulation without acceptance as long as the convenience of the successive holders requires; and it has been found not to be *laches* (in Scotland *mora*, or undue delay) to keep a bill (at three days' sight) out in the circulation for twelve months; but if, instead of circulating, a holder were to lock it up, this would be *laches.* An unacceptable inland bill may also be put into circulation; and any holder, who does not circulate it, has a reasonable time, such as the fourth day respecting a bill drawn within twenty miles of London, for presenting it there for acceptance. Dispatch and attention, however, are always advisable. It is said that when a bill has been already protested for non-acceptance, and due notice thereof given, it is not necessary to protest or to give notice on account of non-payment, but it is usual to do so, and the safer practice. The same rules and the same time should be observed as to non-payment, that are observed as to protest and notice, in the case of non-acceptance. When inland bills are made payable on a day named and fixed in the bills, it is common to delay presenting them for acceptance, until they can also be presented for payment, and then, if necessary, to protest for both; but it is better to make a presentment for acceptance as soon as it can be done in the ordinary course of business. It has already been stated, that notice either of non-acceptance when a presentment has been made, or for non-payment, *must* be given *to all the parties* to whom the *holder* intends to resort for payment. Bankruptcy is no excuse for neglecting any step in the negotiation of a bill. If a party be bankrupt, notice of recourse should be given to him and his assignees; if *dead,* to his executor or administrator; if abroad, the notice should be left at his place of residence, if he have one, and a demand of acceptance or payment (when that is necessary) should be made of his wife or servant. Notice should also be made to one who merely guarantees payment; and a person who subscribes a bill not addressed to him is held to be a collateral security. If notice be made to one indorser, he may give notice to prior indorsers, or to the drawer; and if done timeously, it will be available to the holder; but notice by a party, not party to the bill, nor agent for a party, will not be available.

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Accommodation paper.

Accommodation bills are subject to the same rules as other paper, except among those who agree to lend their names or credit. Among them the rule is, that he for whose use the money is to be raised shall provide for the bill; but as all the others have an action of relief when forced to pay, they are entitled to notice. In Scotland this has been extended to the drawer when he is not the party for whom the credit was intended. With respect to cross paper, it is held that mutual accommodations exchanged are good considerations for each other; that in case of bankruptcy, a dividend from any one estate is to be held as payment of all that can be demanded in respect of that debt; and that there can be no double ranking of the same debt. But questions often arise in such cases, which require the utmost professional skill to comprehend and decide. In a short digest of this nature it is impossible to enter into the niceties of legal questions; and we can only observe generally, that parties should never act in cases of difficulty, without taking the best professional assistance.

Cross paper.

The *law* respecting bills of exchange is more consonant to reason than almost any other branch of our law, since, where it is silent, recourse is had to the custom of merchants.

The best authorities respecting the law of bills are the treatises of Chitty and of Bayley as to English law, and Mr Bell's *Commentaries on Mercantile Jurisprudence* as to Scotch law.

Par of Exchange between England and the following places, viz. Amsterdam, Hamburg, Paris, Madrid, Lisbon, Leghorn, Genoa, Naples, and Venice; the same being computed from the intrinsic Value of their principal Coins, by comparing Gold with Gold, and Silver with Silver, according to their Mint Regulations, and to Assays made at the London and Paris Mints. (Presented by Dr Kelly to the Committee of the House of Lords on the expediency of the Bank's resuming Cash Payments.)

	GOLD.		SILVER.				EXPLANATIONS.
			Old Coinage.		New Coinage.		
	Mint Regulations.	Assays.	Mint Regulations.	Assays.	Mint Regulations.	Assays.	Monies of Exchange.
Amsterdam, banco ..	36 8	36 6,8	37 3	37 10,5	35 0	35 6,5	Schillings and pence Flemish per pound sterling. Agio two per cent.
Amsterdam, current	11 4,5	11 3,8	11 8,5	11 11,8	10 14,6	10 17,6	Florins and stivers per pound sterling.
Hamburg.............	34 3,5	34 1,5	35 1	35 1,3	32 11	32 11,5	Schillings and pence Flemish banco per pound sterling.
Paris....................	25 20	25 26	24 73	24 91	23 23	23 40	Francs and cents per pound sterling.
Madrid.................	37·3	37·2	39·2	39·0	41·7	41·5	Pence sterling for the piastre or dollar of exchange.
Lisbon.................	67·4	67·5	60·41	58·33	64·30	62·69	Pence sterling per milree.
Leghorn...............	49·1	49·0	46·46	46·5	49·60	49·5	Pence sterling per pezza of exchange.
Genoa..................	45·5	45·5	46·46	48·9	49·4	52·0	Pence sterling per pezza fuori banco.
Naples	41·22	......	41·22	......	43·9	.....	Pence sterling per ducat (new coinage of 1818).
Venice	46·3	46·0	47·5	49·0	44·6	46·1	Lire piccole per pound sterling.

Table containing the Value of the Monies of Account of different Places (expressed in Pence and Decimals of Pence), according t the Mint Price both of Gold and Silver in England; that is, L.3 17s. 10½d. per Ounce for Gold, and 5s. 2d. per Ounce for Silve Kelly's *Cambist*, ii. p. 149.

		Value in Silver.	Value in Gold.
		d.	d.
Aix-la-Chapelle,	Rixdollar current	31, 40	31, 43
Amsterdam	Rixdollar banco (agio at 4 per cent.)	52, 54	variable.
	Florin banco	21,	ditto.
	Florin current	20, 72	ditto.
	Pound Flemish current	124, 32	ditto.
Antwerp	Pound Flemish (money of exchange)	123, 25	123, 87
	Florin (money of exchange)	20, 54	20, 64
	Pound Flemish current	105, 65	106, 18
	Florin current	17, 60	17, 70
Barcelona	Libra Catalan	28, 14	26, 70
Basil	Rixdollar, or ecu of exchange	47, 27	47,
	Rixdollar current	42, 45	42, 20
Berlin	Pound banco	47, 25	variable.
	Rixdollar current	36,	ditto.
Berne	Ecu of 3 livres	42, 64	42, 90
	Crown of 25 batzen	35, 53	35, 75
Bremen	Rixdollar current	37, 80	variable.
	Rixdollar in Carls d'or	……	39, 68
Cassel	Rixdollar current	37, 80	variable.
Cologne	Rixdollar specie of 80 albuses	31, 38	ditto.
	Rixdollar current of 78 albuses	30, 60	ditto.
Constantinople	Piastre, or dollar	9, 45	uncer.
Dantzic	Gulden or florin	9,	9,
Denmark	Rixdollar specie	54, 72	……
	Rixdollar crown money	48, 37	……
	Rixdollar Danish currency.	44, 27	44, 88
England	Pound sterling	240,	240,
Florence	Lira	8, 12	8, 53
	Ducat or crown current	56, 84	59, 71
	Scudo d'or, or gold crown	……	63, 97
France	Livre Tournois	9, 58	9, 38
	Franc (new system)	9, 70	9, 52
Francfort	Rixdollar convention money	37, 80	37, 65
	Rixdollar Muntze, or in small coins	31, 50	……
Germany	Rixdollar current	37, 80	variable.
	Rixdollar specie	50, 40	ditto.
	Florin of the empire	25, 20	ditto.
	Rixdollar Muntze	31, 50	ditto.
	Florin Muntze	21,	ditto.
Geneva	Livre current	16, 13	16, 13
	Florin	4, 60	4, 84
Genoa	Lira fuori banco	8,	7, 83
	Pezza, or dollar of exchange	45, 92	45, 50
	Scudo di cambio, or crown of exchange	36, 75	36, 02
Hamburg	Mark banco (at a medium)	18, 22	variable.
	Pound Flemish banco	136, 65	ditto.
	Mark current	14, 82	variable.
	Pound Flemish current	111, 15	ditto.
Hanover	Rixdollar (in cash)	42,	42, 26
	Rixdollar (gold value)	39,	39, 24
Königsberg	Gulden or florin	12,	variable.
Leghorn	Pezza of 8 reals	46, 25	49, 16
	Lira moneta buona	8, 13	8, 55
	Lira moneta lunga	7, 79	8, 19
Leipsic	Rixdollar convention money	37, 80	variable.
	Rixdollars in Louis d'ors or Fredericks	……	39, 68
Malta	Scudo or crown	21, 32	23, 34
Milan	Lira imperiale	10, 41	10, 53
	Lira corrente	7, 45	7, 44
	Scudo imperiale	60, 90	61, 60
	Scudo corrente	42, 32	42, 78
Modena	Lira	3, 72	…..
Munich	Gulden or florin	21,	21, 28
Naples	Ducat of 1818	41, 20	41, 22
Parma	Lira	2, 35	2, 40
Persia	Toman of 100 mamoodis,	287, 60	……
Poland	Gulden or florin	6, 03	6, 27
Portugal	Milree	……	67, 34
	Old crusade	……	26, 94
Riga	Rixdollar Alberts	52, 54	variable.
	Rixdollar currency (agio at 40 per cent.)	37, 53	ditto.
Rome	Scudo or crown	52, 05	51, 63
	Scudo di stampa d'oro	79, 37	78, 73
Russia	Ruble	……	variable.
Sardinia	Lira	18, 21	18, 82
Sicily	Ounce	123, 54	124, 80
	Scudo or crown	49, 02	49, 92
Spain	Real of old plate	4, 88	4, 57
	Real of new plate	5, 18	4, 86
	Real of Mexican plate	6, 48	6, 07
	Real Vellon	2, 59	2, 43
	Dollar of old plate, or of exchange	39,	36, 59
Sweden	Rixdollar	55, 41	56, 43
Switzerland	Franc (new system)	22, 14	……
Trieste	Florin, Austrian currency,	25, 20	25, 05
	Lira, Trieste currency.	4, 76	4, 73
	Lira di piazza	4, 65	4, 63
Turin	Lira	11, 28	11, 23
Valencia	Libra	39, 45	36, 59
Venice	Lira piccola (in the old coins)	5, 07	variable.
	Lira piccola (in the coins introduced by the Austrians)	4, 25	ditto.
Vienna	Florin	25, 20	25, 05
Zante	Real	4, 06	variable.
Zurich	Florin, money of exchange,	25, 85	ditto.
	Florin current	23, 50	ditto.

Exc ge
Ex

Exclusion
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Excommunication.

Exchange also signifies a place in most considerable trading cities, where the merchants, agents, bankers, brokers, interpreters, and other persons concerned in commerce, congregate on certain days, and at certain times of the day, to confer and treat together of matters relating to exchanges, remittances, payments, adventures, assurances, freightments, and other mercantile negotiations, both by sea and land.

In Flanders, in Holland, and in several cities of France, these places are called *Bourses;* at Paris and at Lyons, *Places de Change;* and in the Hanse Towns, *Borsenhalle.* These assemblies are held with so much exactness, and merchants and traders are so indispensably required to attend at them, that a person's absence alone makes him suspected of a failure or bankruptcy. The most considerable exchanges in Europe are, first, that of Amsterdam, and, secondly, that of London, called the Royal Exchange.

Even in the time of the ancient Romans, there were places for merchants to meet, in most of the considerable cities of the empire. That which is said by some to have been built at Rome in the year of the city 259, or 493 years before Christ, under the consulate of Appius Claudius and Publius Servilius, was called *Collegium Mercatorum,* of which it is pretended there are still some remains, called by the modern Romans *Loggia* or the Lodge, and now usually the place of St George. This notion of a Roman exchange is supposed to be countenanced by the authority of Livy.

EXCHEQUER, in British jurisprudence, an ancient court of record, in which all causes concerning the revenues and rights of the crown are heard and determined, and where the crown revenues are received. It derived this name from the cloth that covered the table of the court, which was party-coloured, or chequered. See England, Part III.

Exchequer, in Scotland. See Scotland.

EXCISE (from the Belgic *acciisse,* tribute), an inland duty or impost paid sometimes upon the consumption of the commodity, or frequently upon the sale, which is the last stage before the consumption. This is doubtless, impartially speaking, the most economical way of taxing the subject; the charges of levying, collecting, and managing the excise duties, being considerably less in proportion than in other branches of the revenue. It also renders the commodity cheaper to the consumer than the charging it with customs to the same amount would do, because it is generally paid in a much later stage. But this mode of taxation has ever been unpopular. Lord Clarendon tells us, that to his knowledge the Earl of Bedford, who was made lord treasurer by King Charles I., in order to oblige his parliament, intended to have set up the excise in England; yet it never formed a part of that unfortunate prince's revenue, being first introduced, on the model of the Dutch prototype, by the parliament itself, after the rupture with the crown. Yet such was the opinion of its general unpopularity, that when in 1642 "aspersions were cast by malignant persons upon the house of commons, that they intended to introduce excises, the house for its vindication therein did declare, that these rumours were false and scandalous, and that their authors should be apprehended and brought to condign punishment." Its original establishment was in 1643, and its progress was gradual, being at first laid upon those persons and commodities where it was supposed the hardship would be least perceptible, namely, the makers and venders of beer, ale, cyder, and perry. The royalists at Oxford soon followed the example of their brethren at Westminster, by imposing a similar duty; but both sides protested that it should be continued no longer than till the end of the war, and should then be utterly abolished. The parliament at Westminster, however, soon afterwards imposed it on flesh, wine, tobacco, sugar, and such a multitude of other commodities, that it might be fairly denominated *general;* and this was done in pursuance of the plan proposed by Pym, who seems to have been the father of the excise, in his letter to Sir John Hotham, intimating, "that they had proceeded in the excise to many particulars, and intended to go on farther, but that it would be necessary to use the people to it by little and little." And afterwards, when the nation had been accustomed to it for a series of years, the succeeding champions of liberty boldly and openly declared "the impost of excise to be the most easy and indifferent levy that could be laid upon the people;" so that it continued during the whole of the usurpation. Upon the return of Charles II., as it had then been long established, and its produce was well known, some part of it was given to the crown by 12 Carol. II. as a compensation for the feudal tenures and other oppressive parts of the hereditary revenue. But from its origin to the present time its name has been odious to the people. See Taxation.

EXCLUSION, or *Bill of* Exclusion, a bill proposed towards the close of the reign of King Charles II. for the purpose of excluding the Duke of York, the king's brother, from the throne, on account of his being a Catholic.

EXCOMMUNICATION, an ecclesiastical penalty or censure, by which persons guilty of any notorious crime or offence are separated from the communion of the church, and deprived of all spiritual advantages.

Excommunication is founded on the natural right which all societies have, of excluding from their body such as violate the established laws; and it was originally instituted for preserving the purity of the church; but ambitious ecclesiastics converted it by degrees into an engine for promoting their own power, and frequently inflicted it on the most frivolous pretences.

The power of excommunication, as well as other acts of ecclesiastical discipline, was lodged in the hands of the clergy, who distinguished it into the *greater* and *lesser.*

The *lesser* excommunication, simply called *aphorismos,* separation or suspension, consisted in excluding men from the participation of the eucharist, and the prayers of the faithful. But they were not thereby expelled the church; for they had the privilege of being present at the reading of the Scriptures, the sermons, and the prayers of the catechumens and penitents. This excommunication was inflicted for lesser crimes, such as neglecting to attend the service of the church, misbehaviour in church, and the like.

The *greater* excommunication, called *panteles aphorismos,* or total separation and anathema, consisted in an absolute and entire exclusion from the church and the participation of all its rites. When any person had thus been excommunicated, notice of it was given by circular letters to the most eminent churches, that they might all confirm this act of discipline, by refusing to admit the delinquent to their communion. The consequences of this latter excommunication were terrible. The excommunicated person was avoided in civil commerce and outward conversation; no one would receive him into his house, or eat at the same table with him; and when dead, he was denied the solemn rites of burial.

The Roman pontifical takes notice of three kinds of excommunication: first, the minor, incurred by those who have had any correspondence with an excommunicated person; second, the major, which falls upon those who disobey the commands of the holy see, or refuse to submit to certain points of discipline, in consequence of which they are excluded from the church militant and triumphant, and delivered over to the devil and his angels; and, third, anathema, which is properly that pronounced by the pope against heretical princes and countries. In former ages, these papal fulminations were terrible calamities; but at present they are formidable only to a few petty states of Italy.

Excommunication, in the Greek church, cuts off the offender from all communion with the three hundred and eighteen fathers of the first council of Nice, and with the saints; consigns him over to the devil and the traitor Judas; and condemns his body to remain after death as hard as a flint or piece of steel, unless he humble himself, and make atonement for his sins by a sincere repentance. The form abounds with dreadful imprecations; and the Greeks assert, that if a person die excommunicated, the devil enters into the lifeless corpse; to prevent which, the relations of the deceased cut his body in pieces, and boil them in wine. It used to be a custom for the patriarch of Jerusalem annually to excommunicate the pope and the church of Rome; on which occasion, besides a great deal of idle ceremony, a nail was driven into the ground with a hammer, as a mark of malediction.

The form of excommunication in the church of England anciently ran thus: "By the authority of God the Father Almighty, the Son, and Holy Ghost, and of Mary the blessed mother of God, we excommunicate, anathematize, and sequester from the pale of the holy mother church," and so forth. The causes of excommunication in England are, contempt of the bishop's court, heresy, neglect of public worship and the sacraments, incontinency, adultery, simony, and the like. It is described as twofold. The lesser is an ecclesiastical censure, excluding the party from the participation of the sacraments; the greater proceeds farther, and excludes the party not only from these privileges, but from the company of all Christians. But if the judge of any spiritual court excommunicate a man for a cause of which he has not the legal cognizance, the party may have an action against him at common law, and he is also liable to be indicted at the suit of the king.

Excommunication, or the act of secluding from a participation in the mysteries of religion, was also in use under paganism. Persons thus excommunicated were forbidden to assist at or attend the sacrifices, or enter within the temples; and they were afterwards delivered over to the demons and furies of hell, with certain imprecations. This was called by the Romans *diris devovere.*

Amongst the ancient Britons and Gauls the Druids likewise made use of excommunication against rebels, and interdicted from the communion of their mysteries such as had refused to acquiesce in their decisions.

EXCREMENT, whatever is discharged out of the body of animals after digestion; or the fibrous part of the aliment, mixed with the bile, saliva, and other fluids. Urine and the fæces are the gross excrements discharged out of the bladder and stomach. The other excrements are the various humours secreted through the different pores of the body, by which secretion several useful purposes are served.

EXCRESCENCE, in *Surgery*, denotes every preternatural tumour which arises upon the skin, either in the form of a wart or a tubercle. If such tumours are born with a person, as is frequently the case, they are called *nævi materni*, or marks from the mother; but if they are large, so as to depend from the skin, like a fleshy mass, they are then called *sarcomata.*

EXCRETORY, in *Anatomy*, a term applied to certain little ducts or vessels, destined for the reception of a fluid, secreted in certain glandules and other viscera, for the excretion of it in the appropriated places.

EXCUBIÆ, in *Antiquity*, the watches and guards kept in the daytime by the Roman soldiers. They are contradistinguished from the *vigiliæ*, which were kept in the night. The *excubiæ* were placed either at the gates and entrenchments, or in the camp; for the latter there was allowed a whole *manipulus* to attend before the *prætorium*, and four soldiers to the tent of every *tribune.* The *excubiæ* at the gates of the camp, and at the entrenchments, were properly called *stationes.* One company of foot and one troop of horse were assigned to each of the four gates every day. To desert his post, or to abandon his corps of guards, was an unpardonable crime in the Roman soldier.

The *triarii*, as the most honourable class of soldiers, were excused from the ordinary watches; yet being placed opposite to the *equites*, they were obliged to have an eye over them.

EXCUSATI, in *Ecclesiastical History*, a term used to denote slaves, who, having fled to any church for sanctuary, were excused and pardoned by their masters; but the latter were obliged to take an oath to this effect before they could recover the fugitives; and, if they broke it, they were punished and fined as persons guilty of perjury.

EXEAT, in church discipline, a Latin term used for a permission which a bishop grants a priest to go out of his diocese, or an abbot to a religious person to go out of his monastery.

EXECRATION, in *Antiquity*, a kind of punishment, consisting of direful curses and marks of infamy, such as was used against Philip, king of Macedonia, by the Athenians. A general assembly of the people being called, they made a decree that the statues and images of that king, and of all his ancestors, should be demolished, and their very name erazed; that all the festivals, sacred rites, and whatsoever else had been instituted in honour of him, should be profaned; that the very places where there had been any monument or inscription to his honour should be detestable; that nothing should be set up or dedicated in them, which could be done in clean places; and, lastly, that the priests, as often as they prayed for the Athenian people, allies, armies, and fleets, should detest and execrate Philip, his children, kingdom, land and sea forces, and the whole race and name of the Macedonians.

At the taking and demolishing of cities, it was usual amongst the Jews, Greeks, and Romans, to pronounce curses upon, and load with direful execrations, those who should rebuild them.

EXECUTIVE POWER. The supreme executive power of these kingdoms is vested by our laws in a single person, the king or queen for the time being.

The executive power in Britain has a right to a negative or *veto* in parliament; that is, to refuse assent to any acts presented for that purpose, otherwise the two other branches of legislative power might become despotic.

EXECUTOR, a person nominated by a testator, to see his will and testament executed or performed, and his effects disposed of according to the tenor of such will and testament. See LAW.

EXECUTOR, in *Scotch Law*, signifies either the person entitled to succeed to the moveable estate of one deceased, or who by law or special appointment is entrusted with the administration of it.

EXECUTRY, in *Scotch Law*, is the moveable estate falling to the executor. Under executry or moveables is comprehended every thing that moves itself, or that can be moved.

EXEDRÆ, in *Antiquity*, denoted halls with many seats, where the philosophers, rhetoricians, and men of learning met for discourse and disputation. The word occurs in

Exfoliation
||
Exhaustions.

ecclesiastical writers as a general name for such buildings as were distinct from the main body of the churches, and yet within the limits of the church taken in its largest sense. Among the exedræ the chief was the baptistery.

EXEGESIS, a discourse, by way of explanation or comment, upon any subject.

EXEGETES (formed from εξηγεομαι, *to explain*), among the Athenians, persons learned in the laws, whom the judges used to consult in capital causes.

EXEGETICA, in *Algebra*, the art of finding, either in numbers or lines, the roots of the equation of a problem, according as the problem is either numerical or geometrical.

EXEMPLAR, a model or original to be imitated or copied.

Exemplar also denotes the idea or image conceived or formed in the mind of the artist, and according to which he conducts his work.

EXERCISE, amongst physicians, such movement and agitation of the body as produce salutary effects in the animal economy.

Exercise may be said to be either active or passive. Active exercise consists in walking, hunting, dancing, playing at bowls, and the like; as also in speaking and other labours of the body and mind. Passive exercise consists in riding in a coach, on horseback, or in any other manner. Boerhaave recommends bodily exercise in diseases of a weak and lax fibre. By riding on horseback, says his commentator, the pendulous viscera of the abdomen are shaken every moment, and gently rubbed as it were one against another, whilst in the mean time the pure air acts on the lungs with greater force. Sailing in a ship is also an exercise of great use to weak people. If the vessel proceeds with an even motion, by increasing perspiration it usually excites a wonderful alacrity, creates an appetite, and promotes digestion. These exercises are more especially serviceable to weak people; but, in order to strengthen the body by muscular motion, running and bodily exercises are to be used. In the latter, however, persons should begin with the most gentle, such as walking, and increase it by degrees till they come to running. Those exercises of the body are most especially serviceable which at the same time give pleasure or occupation to the mind, as tennis, fencing, and the like; for which reason, the wisdom of antiquity appointed rewards to those who excelled in gymnastic exercises, that the bodies of their youth might be prepared for enduring warlike toils.

Exercise, in military affairs, is the ranging a body of soldiers in order of battle, and making them perform the several motions and military evolutions necessary to render them expert in the use of their arms. See War.

EXERGUM, among antiquaries, a little space around or without the figures of a medal, left for the inscription, cipher, device, date, and so forth.

EXETER, a large city, the capital of the county of Devon, 170 miles from London. It rises gradually from the banks of the river Ex; and the whole city being on a declivity, it is remarkably clean, notwithstanding the narrowness of all but the principal street. The best parts are without the line of the ancient walls; and both the suburbs of Southernay and Nornay are beautiful and well built. The surrounding country is highly fruitful, affording good corn, pasture, dairy, and fattening land, and abounding in fruit, especially apples, from which the best of cider is plentifully yielded. These circumstances, with the cheapness of fish and poultry, and the salubrity of the air, contribute to attract to Exeter numerous families of easy but moderate fortune.

Exeter was formerly the emporium of the thinner kind of woollen goods, such as serges, druggets, estamines, and long ells, which were spun and woven in the towns around, and dyed and finished within the city. From thence they were shipped to Holland, Italy, and especially to Spain, and many were supplied to the East India Company; but the introduction of machinery, and the lower price of fuel in the north of England, have now nearly destroyed those branches of trade, with the exception of that for the supply of India, which is still considerable. As Exeter is a kind of metropolis for Devon and Cornwall, it has considerable internal trade, and is the channel by which these counties are supplied with many foreign commodities. The river Ex is so far navigable that, by means of locks, vessels of 150 tons burden can come up to the city; but those of greater draught of water remain at Topsham, three miles lower, and the largest of all at Exmouth, at the mouth of the river. Exeter contains a cathedral and fifteen other churches, besides several other places of worship for the separatists from the establishment. The cathedral is a magnificent pile, a part being very old, but many additions are of more recent construction, though on the plan originally formed. The western window is an object of peculiar admiration. The see includes nearly the whole of Devonshire and Cornwall. It was first founded at Bodmin, then transferred to Taunton, afterwards to Crediton, and finally, in 1094, to Exeter. The city is governed by a corporate body, consisting of the mayor, twenty-four aldermen, and other officers. Two members are returned to the House of Commons. The markets are held on Wednesday and Friday, and there is a good fish-market daily. The population amounted in 1801 to 16,827, in 1811 to 18,896, in 1821 to 23,479, and in 1831 to 28,201.

EXFOLIATION, a term used by surgeons for the separation of the dead part of a bone from the living part.

EXHALATION, a general term for all effluvia or steams raised from the surface of the earth in form of vapour.

EXHAUSTIONS, in *Mathematics*. The method of exhaustions is a way of comparing or estimating fixed magnitudes by means of variable magnitudes, which may be brought to approach or *exhaust* them more nearly than any assigned interval or remainder.

Thus, a regular polygon may be inscribed in a circle, and by repeatedly doubling the multitude of sides, or increasing it by other given laws, this variable figure may be made so to *exhaust* the circle as to leave a remainder less than any given area. And because similar polygons inscribed in different circles have always the duplicate ratio of the diameters, it has been perceived that the circles themselves must be as these exhaurient polygons, which Euclid proves strictly by the method of exhaustions.

A rectilineal figure may be inscribed in a segment of a parabola, so as to leave less of the parabola than any area assigned, and also to be nearer four thirds of the greatest inscribed triangle than any given difference. Hence Archimedes proves, by the method of exhaustions, that the segment of the parabola exceeds the triangle by one third of the same triangle.

The first lemma of Newton's *Principia* brings the method of exhaustions to general application. It is in these words:

"Quantitates, ut et quantitatum rationes, quæ ad æqualitatem tempore quovis finito constanter tendunt, et ante finem temporis illius propius ad invicem accedunt quam pro data quavis differentia, fiunt ultimo æquales.

"Si negas; fiant ultimo inæquales, et sit earum ultima differentia D. Ergo nequeunt propius ad æqualitatem accedere quam pro data differentia D: contra hypothesin."

Many authors have not rightly understood this lemma, as Horsley in his note upon it; Hutton on Prime and

Ultimate Ratios, in his *Dictionary;* and Woodhouse, *Principles of Analytical Calculation,* paragraph 105, where it is said to be "merely a definition," and, again, that "it gave a new signification to the term equality."

If our opinion be just, it gives no signification to the term equality which was not given by Euclid and Archimedes. The novelty is in giving to the word *ultimate,* or the adverb *ultimately,* an extension beyond what it ordinarily includes; as, in the technical language of the *Principia,* things are often said to be *ultimately* what, by their definition, they are incapable of becoming.

In this language, as explained by its author, an ultimate quantity, or that which a quantity ultimately becomes (*fit ultimo*), is what is otherwise called the *limit* of the quantity; that to which, repeating the words of this lemma, *tempore quovis finito constanter tendit, et ante finem temporis illius propius accedit quam pro data quavis differentia.* Thus, in the *Scholium,* after the eleventh lemma, our author says, *ad ultimas quantitatum evanescentium summas, id est, ad limites summarum.*

Few as are the words of the demonstration of this celebrated lemma, it must be concluded from them that it only concerns quantities of which it could be questioned whether they have a *fixed* difference. Applied to variables, it can therefore only compare them in some simultaneous magnitudes. Among simultaneous magnitudes, Newton, for the sake of brevity, includes limits; and, in fact, only these limits are here compared. Perhaps a slight change in the language may show more clearly the intention.

"Quantities, as also the ratios of quantities, which in any finite time soever constantly tend to equality, and before the end of that time approach nearer than any difference, have equal limits."

"If not, let their limits be unequal, and differ by D. Then the variables, in their approach, cannot come nearer than D, *contra hypothesin.*"

This may be too concise, but is fully made out in the following manner:

Let X and Y be two quantities, continually approaching, and capable of being brought nearer than any difference within a finite time. Let A be the limit of X, and B the limit of Y; that is, let A and B be fixed quantities, to which X and Y, during their approach, may be brought nearer than any difference assignable. Then shall A and B be equal.

For, if not, let $A = B + D$. And at any time during the approach of X and Y, let m be the difference of X from its limit, and n the contemporary difference of Y from its limit. And,

I. Suppose the variables to approach by the decrease of the greater and the increase of the less towards their respective limits (like a circumscribed and inscribed polygon); or $X = A + m$, $Y = B - n$. Then $X - Y = A - B + m + n = D + m + n$, so that X and Y necessarily differ by more than D, *contra hypothesin.*

II. Suppose both variables to decrease towards their limits; or $X = A + m$ and $Y = B + n$. Then $X - Y = A - B + m - n = D + m - n$.

Now if n were greater than m, we might decrease Y by a part of n, which we will call y, greater than m itself, and still greater than its part (x), the contemporary decrement of X; and putting X′ and Y′ for the variables thus decreased, we should have $X' = X - x$, $Y' = Y - y$, and thence $X - Y' = X - Y + (y - x)$; so that the difference of the variables would be augmented by bringing them nearer to their limits. Therefore n cannot be greater than m; consequently $D + m - n$ cannot be less than D, or the difference of X and Y cannot become less than D, *contra hypothesin.*

III. It only remains to examine the case where both increase towards their limits, or $X = A - m$, $Y = B - n$, and $X - Y = A - B + n - m = D + n - m$.

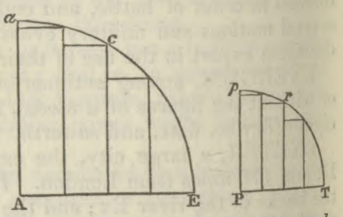
Here if m exceeded n, we might increase X by a quantity x greater than n, and still more exceeding y, the contemporary increment of Y, and putting X′ and Y′ to signify the variables thus increased, $X' - Y' = X + x - (Y + y)$, or $X' - Y' = X - Y + (x - y)$, so that the variables would again diverge. Therefore again $D + n - m$ cannot be less than D, or X and Y cannot differ by less than D, *contra hypothesin.*

If X, Y, A, B, D, m, n, x, y, represent *measures of ratios,* the proof includes the *quantitatum rationes.*

There results no absurdity from supposing the limits of two quantities which continually approach to have a difference D; but then the approaching quantities must always differ still more, contrary to one of the conditions.

By making n nothing in Case II. we make Y constant, and coincident in magnitude with B. The proposition obtained by the reasoning is, for this case, that whatever quantity A (suppose it a parabolic segment) may be an acknowledged limit of a variable X, if X can at the same time be proved to approach indefinitely to Y or B (suppose it a triangle equal to four thirds of the greatest triangle in the parabolic segment), A is equal to B. This is to prove that limits of the same variable are equal, which is neither giving a new signification to equality, nor concluding an identical proposition, nor indeed one which an ancient geometer would have admitted without formal proof. We come to a similar conclusion by making m nothing in Case III.

It is true that, in the *Principia,* when a fixed quantity is proved to be a limit to a variable, and the variable then pronounced ultimately equal to the fixed quantity, the author or editors refer to the first lemma, when reference might as well be made to the definition of ultimate quantities there implied; only (what is the main thing) the demonstration of the lemma teaches how, by admitting the limit as a particular value of the variable, we cannot produce an error measured by any fixed quantity, while if an error were admitted at all, it *must* be of fixed amount. Thus in Lemma IV. where the same multitude of rectangles is supposed to be inscribed in the two figures A*ac*E, P*pr*T, and when this multitude is indefinitely increased, and consequently the breadth of the rectangles and the remainder of the areas indefinitely diminished, each rectangle in the one figure has, by hypothesis, the same ratio to a corresponding rectangle in the other; it is concluded that this is also the ratio of the whole figures. For the ratio of the area A*ac*E to P*pr*T may be viewed as compounded of A*ac*E to the rectangles within itself, of these to the contemporary rectangles within P*pr*T, and of these latter rectangles to P*pr*T. But the first and last of the component ratios being *ultimately* of equality, the compound ratio is the constant ratio of the contemporary rectangles. For let L be the measure of the ratio of the inscribed rectangles, and let it be asserted that the compound ratio differs from L by a ratio whose measure is D. The first and last of the component ratios being ultimately of equality, their contemporary values may be made such that the measures (m and n) of the ratios by which the former exceeds equality and the latter falls below it, may be each less than D, and, *a fortiori,* their difference less than D. But $L + m - n$ is the true measure of the compound ratio; therefore L does not differ from the true measure by D.



Thus, by admitting ultimate values, no error is admitted. The method of exhaustions, which Newton's first lemma reduces to an enunciable proposition, only requires it to be allowed that fixed quantities either have a fixed difference or are equal. What is often called the principle of limits is to comprehend limits at once in the conclusion of a demonstration which does not apply to them. Newton's lemma serves to admit them through the method of exhaustions. According to the foregoing exposition, it is neither an identical proposition nor an arbitrary extension of the meaning of a term, though these inconsistent charges have both been brought against it. A and B are proved to be equal in the old signification of equality; and whilst it is said that X and Y are *ultimately* equal, X and Y are also ultimately A and B. (O. O. O.)

EXHEREDATION, in the civil law, is the father's excluding his sons from inheriting his estate.

There are fourteen causes of exheredation, expressed in Justinian's *Novellæ*, without some one of which he declares the exheredation null, and the testament inofficious, as the civilians express it. Indeed, by the ancient Roman law, the father might pronounce exheredation without any cause; but the rigour of this law was restrained and moderated by Justinian.

EXHIBITION, in *Law*, a producing or showing of titles, authorities, and other proofs, in a matter contested.

EXHIBITION, in our old writers, is used to signify an allowance of meat and drink, such as was customary amongst the religious appropriators of churches, who usually made it to the vicar incumbent. The benefactions settled for the maintaining of scholars in the universities not depending on the foundation, are also called *exhibitions.*

EXHORTATION, in *Rhetoric*, differs only from *persuasion* in that the latter principally endeavours to convince the understanding, and the former to work on the affections.

EXIGENTERS, four officers in the court of common pleas, who make exigents and proclamations in all actions where process of outlawry lies.

EXILE. Among the Romans, the word *exilium* properly signified an interdiction or exclusion from water and fire; the necessary consequence of which was, that the interdicted person had to betake himself to some other country, as there was no living without fire and water in his own. Thus Cicero observes, that the form of the sentence did not express *exilium*, but only *aquæ et ignis interdictio;* and he also remarks that exile was not properly a punishment, but a voluntarily flying from or avoiding the punishment decreed: *Exilium non esse supplicium, sed perfugium portusque supplicii.* He adds that there was no crime among the Romans, as among other nations, punished with exile; but exile was a resource of which people voluntarily availed themselves, in order to avoid chains, ignominy, famine, or death.

The Athenians frequently sent their generals and great men into exile, out of envy of their merits, or distrust of their authority and influence in the state.

EXISTENCE, that by which any thing has an actual essence, or is said to *be.* See METAPHYSICS.

EXIT properly expresses the departure of a player from the stage, when he has performed his part. The word is also used in a figurative sense, to express any kind of departure, even death.

EXITERIA, in *Antiquity*, oblations or prayers to any of the gods for a prosperous expedition or journey. There were also feasts under this denomination, which were celebrated by the Greeks with sacrifices and prayers, when their generals undertook expeditions against an enemy.

EXMOUTH, a town in Devonshire, 166 miles from London, part of the parish of Littleham, and part of Withycombe Rawleigh, in the hundred of East Budleigh. It is situated on the north side of the Ex, at its entrance into the sea. It has risen within a few years, from having become the resort of company for sea-bathing in summer, and in winter the residence of those suffering under pulmonary complaints. The air is salubrious, and the prospects around are beautiful. The population of Exmouth amounted in 1801 to 1909, in 1811 to 2294, and in 1821 to 2640.

EXODIARY, in the ancient Roman tragedy, was the person who, after the drama or play was ended, sung the *Exodium.*

EXODIUM, in the ancient Greek drama, one of the four parts or divisions of a tragedy, being as much of the piece as included the unravelling and catastrophe of the plot, and answering nearly to our fourth and fifth acts.

EXODIUM, amongst the Romans, consisted of certain humorous verses rehearsed by the exodiary at the end of the *Fabulæ Atellanæ.*

EXODIUM, in the Septuagint, signifies the end or conclusion of a feast; and, in particular, it is used for the eighth day of the feast of tabernacles, which, it is said, had a special view to the commemoration of the *exodus* or departure out of Egypt.

EXODUS, a canonical book of the Old Testament, being the second of the Pentateuch or five books of Moses; so called from the Greek word ἔξοδος, the going out or departure of the children of Israel from the land of Egypt; the history of which is delivered in this book, together with that of many miracles wrought on the occasion.

EXORCISM, the expelling of devils from persons possessed, by means of conjurations and prayers. The Jews made great pretences to this power; and Josephus tells several wonderful tales of the success of several performers in this line. According to him, a pretender named Eleazer cured many dæmoniacs by means of a root set in a ring. This root, with the ring, was held under the patient's nose, and the devil forthwith evacuated the tenement of which he had taken possession. The most part of the conjurors of this class were impostors, each pretending to a secret nostrum or charm, which was an overmatch for the devil.

Exorcism forms no inconsiderable part of the religious system of the church of Rome, the rituals of which forbid the exorcising of any person without the bishop's leave. The ceremony is performed at the lower end of the church, towards the door. The exorcist first signs the possessed person with the figure of the cross, makes him kneel, and sprinkles him with holy water; then follow the litanies, psalms, and prayer; after which the exorcist asks the devil his name, and adjures him by the holy mysteries of the Christian religion not to afflict the person possessed any more. Then, laying his right hand on the dæmoniac's head, he repeats the form of exorcism as follows: "I exorcise thee, unclean spirit, in the name of Jesus Christ; tremble, O Satan, thou enemy of the faith, thou foe of mankind, who hast brought death into the world, who hast deprived men of life, and hast rebelled against justice; thou seducer of mankind, thou root of evil, thou source of avarice, discord, and envy." Houses and other places supposed to be haunted by unclean spirits are likewise exorcised; and the ceremony is much the same as that for persons possessed.

EXORCISTS, in *Ecclesiastical History*, an order of men in the ancient church, whose employment it was to exorcise or cast out devils.

EXORDIUM, in *Oratory*, is the preamble or beginning, which serves to prepare the audience for the rest of the discourse. Exordiums are of two kinds, either just and formal, or vehement and abrupt. The latter are more suitable on occasions of extraordinary joy, indignation, or excitement.

EXOTERIC and Esoteric are terms denoting *external* and *internal*, and applied to the double doctrine of the ancient philosophers, particularly those of the Peripatetic school. The one was public or *exoteric;* the other secret or *esoteric.* The first was that which they openly professed and taught to the world; the latter was confined to a small number of chosen disciples. This method was derived originally from the Egyptians, who, according to the united testimony of Herodotus, Diodorus Siculus, Strabo, Plutarch, and others, had a twofold philosophy; one secret and sacred, another public and common. The same practice also obtained amongst the Persian Magi, the Druids of the Gauls, and the Brahmins of India. The Egyptian priests with whom it originated sustained the character of judges and magistrates, and probably introduced this distinction with a view to the public welfare, and to serve the purposes of legislation and government. Clemens Alexandrinus informs us, that they communicated their mysteries principally to those who were concerned in the administration of the state; and Plutarch confirms this declaration. Others, however, have supposed that they invented the fables of their gods and heroes, and the external ceremonies of their religion, to disguise and conceal natural and moral truths; but whatever may have been the motive of their practice, it was certainly applied to political purposes.

EXOTIC, a term properly signifying *foreign* or *extraneous*, that is, brought from a remote or strange country. In this sense we sometimes say *exotic* or *barbarous terms*, and the like. The word is derived from the Greek εξω, or εξωθεν, *extra*, without, or on the outside.

Exotic is chiefly applied to plants which are natives of foreign countries, particularly those brought from the East or West Indies, and which do not naturally grow in Europe.

EXPANSION, in *Physics*, denotes the enlargement or increase of bulk in bodies, chiefly by means of heat. This is one of the most general effects of that subtile principle, and common to all bodies whatever, whether solid or fluid. In some few cases, indeed, bodies seem to expand as they grow cold, as water in the act of freezing; but this is found to be owing to a new arrangement of the particles, or to crystallization, and is not at all a regular and gradual expansion like that of metals, or any other solid or fluid substance by means of heat. In certain metals also, an expansion takes place when they pass from a fluid to a solid state; but this too is not to be accounted any proper effect of cold, but of the arrangement of the parts of a metal in a peculiar manner; and it is therefore to be ascribed to a kind of crystallization.

EXPECTATION, in the doctrine of chances, is applied to any contingent event, and is capable of being reduced to the rules of computation. Thus a sum of money in expectation when a particular event happens, has a determinate value before that event arrives; so that if a person is to receive any sum, say L.10, when an event takes place which has an equal probability of happening and failing, the value of the expectation is half that sum, or L.5; and in all cases the expectation of obtaining any sum is estimated by multiplying the value of the sum expected by the fraction which represents the probability of obtaining it. The expectation of a person who has three chances in five of obtaining L.100, is equal to $\frac{3}{5} \times 100$, or L.60, and the probability of obtaining L.100 in this case is equal to $\frac{60}{100} = \frac{3}{5}$.

Expectation of Life signifies that share or number of the years of human life, which a person of any given age may expect to enjoy upon an equality of chances. See Annuities.

EXPERIENCE, a kind of knowledge acquired by long use, without any teacher or particular course of inquiry.

EXPERIMENTAL Philosophy is that which has its foundation in experience, wherein nothing is assumed as a truth but that which is founded upon ocular demonstration, or which cannot be denied without violating the common sense and perceptions of mankind. See Philosophy and Physics.

EXPERIMENTUM Crucis, a capital, leading, or decisive experiment, which is so termed, either on account of its being like a cross, or direction-post placed in the meeting of several roads, guiding men to the true knowledge of the nature of that thing they are inquiring after; or on account of its being a kind of torture, by means of which the nature of the thing is as it were extorted by force.

EXPIATION, a religious act, by which satisfaction or atonement is made for the commission of some crime, the guilt done away, and the obligation to punishment cancelled.

Expiations amongst the heathens were of several kinds, as sacrifices and religious washings. They were used for effacing a crime, or averting any calamity, and on numberless other occasions, as purifying towns, temples, and sacred places, and armies before and after battle; and they were performed in behalf of whole cities, as well as of particular persons.

The method of expiation amongst the Jews was chiefly by sacrifice, whether for sins of ignorance, or in order to purify themselves from certain pollutions.

Feast of Expiation, amongst the Jews, called by our translators the Day of Atonement, was held on the tenth day of Tisri, or the seventh month of the Jewish year, answering to part of our September and October. On that day the high-priest entered into the holy place, confessed his sins, and, after several ceremonies, made an atonement for all the people, in order to cleanse them from their sins.

EXPLOSION, a sudden and violent expansion of an aerial or other elastic fluid, by which it instantly throws off any obstacle that happens to be in the way, sometimes with great force, and in such a manner as to produce astonishing effects upon adjacent objects.

Explosion differs from expansion, which is a gradual and continuous power, acting uniformly for some time, whereas the former is always sudden, and only of momentary duration. The expansions of solid substances do not terminate in violent explosions, on account of their slowness, and the small space through which the metal, or other expanding substance, moves; though their strength may be equally great with that of the most active aerial fluids. Thus we find, that though wedges of wood, when moistened, will cleave solid blocks of stone, they never throw them to any distance, as is the case with gunpowder. On the other hand, it is seldom that the expansion of any elastic fluid bursts a solid substance without projecting the fragments of it to a considerable distance. The reasons of this are, first, the immense velocity with which the aerial fluids expand, when affected by a considerable degree of heat; and, secondly, their celerity in acquiring heat and being affected by it, which is much superior to that of solid substances. Thus, air, heated as much as iron when brought to a white heat, is expanded to four times its bulk; but the metal itself will not be expanded the five hundredth part of its bulk. In the case of gunpowder, which is a violent and well-known explosive substance, the velocity with which the flame moves is calculated by Mr Robins, in his *Treatise upon Gunnery*, to be no less than seven thousand feet in a second, or little less than seventy-nine miles per minute. Hence the impulse of the fluid is inconceivably great, and the obstacles on which it strikes are hurried off with vast velocity, though much less than that just mentioned; for a cannon bullet, with the greatest charge of powder that can be conveniently given, does not move at a greater rate than two thousand four hundred feet per second, or little more than twenty-seven miles per minute. The velocity of the bullet, again, is promoted by the sudden propagation of the heat through the whole body of air, as soon as it is extricated from the materials of which the gunpowder is made; so that it is enabled to strike all at once, and thus greatly to augment the momentum of the ball. That this contributes much to the force of the explosion, is evident from what happens when powder is wetted or mixed with any substance, which prevents its taking fire all at once. In this case the force of the explosion, even when the same quantity of powder is made use of, cannot be compared to that of dry powder.

Upon these principles we may conclude that the force of an explosion depends, first, on the quantity of elastic fluid to be expanded; secondly, on the velocity it acquires by a certain degree of heat; and, thirdly, on the celerity with which the degree of heat affects the whole of the expansive fluid. These three take place in the greatest perfection where the electric fluid is concerned, as in cases of lightning, earthquakes, and volcanoes. In violent lightning, where the electric fluid collects itself into balls, the strength of the explosion is proportional to the quantity. Every one has heard of the prodigious effects of lightning when it happens to strike buildings, trees, or even the most solid rocks; and in some cases, where the quantity of electricity is still greater than in any flash of lightning, we hear of still more tremendous consequences ensuing. Dr Priestley gives an instance of a large fire-ball, or quantity of electric matter, rolling on the surface of the sea, which, after rising up to the topmast of a ship of war, burst with such violence, that the explosion resembled the discharge of hundreds of cannon fired at once. Great damage was done by it; but there is not the least doubt that most of its force was spent on the air, or carried down to the sea by the mast and iron work of the ship. Considering, indeed, that in all cases a great part of the force of electrical explosions is dissipated in this manner, it may reasonably be doubted whether they can be measured by any method applicable to the mensuration of other forces.

In those cases where the electrical matter acts like common fire, the force of the explosions, though exceedingly great, is capable of mensuration by comparing the distances to which the bodies are thrown with the weight of such bodies. This is most evident in volcanoes, where the projections of the burning rocks and lava manifest the greatness of the power, at the same time that they afford a method of measuring it. By means of the electric fire which kindles the volcanoes, the aerial fluids are suddenly restored to their elastic state; and not only so, but their natural elasticity is greatly augmented, so that the explosions take place with great violence. The case is the same with gunpowder.

Next in strength to the aerial vapours are those of aqueous and other liquids. The most remarkable effects of these are observed in steam-engines; but there is one particular case from which it has been inferred that aqueous steam is vastly stronger than the flame of gunpowder. This is when water is thrown upon molten copper; for here the explosion is so strong as almost to exceed imagination; and the most terrible accidents have been known to happen from such a slight cause as one of the workmen spitting in the furnace where copper was being melted.

In explaining the phenomenon in question, Dr Black supposes that the mere heat of the metal applied to the aqueous steam produces the explosion; and in proof of this he alleges, that copper imbibes a greater quantity of heat during fusion than any other metal. Aqueous steam, however, seems to be too slow for producing such sudden and violent effects. Explosions, it is true, will be occasioned by it, but then it must be confined for a considerable time; whereas the effects of water thrown upon molten copper are instantaneous.

It may now be asked, why such explosions do not take place when water is thrown upon the surface of any other metal, for instance iron, when in a state of fusion? In answer to this it may be observed, that though water is decomposed by being applied to red-hot iron in the form of steam, yet there is a possibility, that when the same element is applied in substance to the fluid metal, no decomposition may ensue. Something like this indeed happens with copper itself; for, notwithstanding the violent effects which take place on the contact of water in substance with the molten metal, no explosion happens from aqueous steam being blown upon its surface. On the contrary, the upper part of the metal is thus cooled, and forms itself into cakes, which are afterwards taken off, and new ones formed in the same manner. Neither does aqueous steam affect red-hot copper in the manner that it does iron in the same state. A decisive proof that the explosion is not occasioned by the mere heat of the aqueous steam may be deduced from the example of molten glass, which produces no explosion though we pour water upon it in that state; and yet the heat of glass in a state of fusion is undoubtedly equal at least to that of molten copper. It may be observed, however, that in all cases where a very hot body is thrown upon a small quantity of water in substance, an explosion will follow; but here the water is confined, and suddenly rarefied into steam, which cannot escape without throwing off the body which confines it. Examples of this kind frequently occur where masons or other mechanics are employed in fastening cramps of iron into stones; if there happen to be a little water in the hole into which the liquid lead is poured, the latter will fly out in such a manner as sometimes to occasion serious accidents. Occurrences of this kind have sometimes happened in founderies, when large quantities of molten metal have been poured into wet moulds. In these cases, the sudden expansion of the aqueous steam throws out the metal with great violence; and if any decomposition take place at the same time, so as to convert the aqueous into an aerial vapour, the explosion will be still greater.

To this last kind of explosion we must refer that which takes place on pouring cold water into boiling or burning oil or tallow. Here the case is much the same whether we pour the oil on the water, or the water on the oil. In the former case, the water, which lies at the bottom, is rarefied into steam, and explodes; in the latter, it sinks down through the oil by its superior specific gravity, and explodes as it passes along. In either case, however, the quantity of aqueous fluid must be but small in proportion to that of the oil; a very great quantity would put out the flame, or destroy the heat, in whatever way it might be applied.

Another kind of explosion is that which takes place in solid substances, where we can scarcely suppose either aqueous or aerial vapours to be concerned. The most remarkable of these are the "volcanic bombs" mentioned by Sir William Hamilton in his account of the great eruption of Vesuvius in the year 1779. They were large pieces of lava, and burst like bombs as they fell to the ground; but he does not inform us whether their bursting was attended with any great violence or not. Other examples are the bursting of electrical globes when put in motion; of other glass vessels exploding spontaneously, and seemingly without any cause; and the bursting of large cast metal vessels in the act of cooling. These are all so similar to one another, that it is probable they depend on one general cause; and all of them agree in this, that the extreme parts are considerably cooled, whilst the internal remain very hot.

The effects of explosions, when violent, are felt at a considerable distance, by reason of the concussions they give to the atmosphere; for all of them act upon the atmospherical fluid with the same force which they exert upon terrestrial substances subjected to their action. Sir William Hamilton relates, that in consequence of the explosions of Vesuvius in 1767, the doors and windows of the houses at Naples flew open if unbolted, and one door was burst open though it had been locked; and the same thing happened several years ago, when the Stobbs powder-mills, near Dalkeith, containing several tons of powder, blew up.

EXPONENT, in *Algebra*, the same with index.

Exponent is also used in arithmetic, in the same sense as index or logarithm.

Exponential Calculus, the method of differencing, or finding the fluxions of exponential quantities, and of summing up those differences, or finding their fluents.

Exponential Curve is that the nature of which is defined or expressed by an exponential equation; as the curve denoted by $a^x = y$, or by $x^x = y$.

Exponential Equation is one in which is contained an exponential quantity; as the equation $a^x = b$, or $x^x = ab$, and the like.

Exponential Quantity is that the power of which is a variable quantity; as the expression a^x, or x^y. Exponential quantities are of several degrees and orders, according to the number of exponents or powers.

EXPOSING, the act of putting out a thing to public view. In the Roman Catholic church the sacrament is said to be *exposed*, when it is shown in public uncovered, on festival days and during the time of plenary indulgences.

Exposing of Children, a barbarous custom practised by most of the ancient nations, excepting the Thebans, who had an express law by which it was made capital to expose children, and at the same time ordained that such as were not in a condition to educate their offspring should bring them to the magistrates, that they might be brought up at the public expense. Amongst the other Greeks, when a child was born, it was laid on the ground; and if the father designed to educate it, he immediately took it up, but if he forbore to do so, the child was carried away and exposed. The Lacedæmonians indeed had a different custom: with them all new-born children were brought before certain persons, who were among the gravest in their own tribes, by whom the infants were carefully examined; and if the latter were found lusty and well favoured, orders were given for their education, and a certain proportion of land allotted for their maintenance; but if weakly or deformed, they were ordered to be cast into a deep cavern in the earth, near the mountain Taygetus, as it was thought neither for the good of the infants themselves nor for the public interest, that defective children should be brought up. Many persons exposed their children only because they were not in a condition to educate them; and it was the unhappy fate of daughters especially to be thus treated, as it required more to educate and settle them in the world than sons.

The parents frequently tied jewels and rings to the children whom they exposed, or any other thing by which they might afterwards discover them, if Providence provided for their safety; or perhaps the design was either to encourage such as found them to nourish and educate them, if alive, or to give them human burial if dead. The places where it was usual to expose children were such as people frequented most. This was done in order that they might be found and taken up by compassionate persons who were in circumstances to defray the expense of their education. With this intention the Egyptians and Romans chose the banks of rivers, and the Greeks the highways and thoroughfares.

EXPOSITION, in general, denotes the setting a thing open to public view.

Exposition, in a literary sense, is the explaining an author, passage, writing, or the like, and setting the meaning in an obvious and clear light.

EXPOSITOR, or Expository, a title which some writers have given to a lesser kind of dictionary or vocabulary, serving to expound or explain the meaning of the obscure or difficult words of a language. It is also used in the same sense with commentary and paraphrase.

EX-POST-FACTO, in *Law*, denotes something done after another thing that was done before.

EXPOSTULATION, in *Rhetoric*, an address to a person who has done another some injury, representing the wrong in the strongest terms, and demanding redress.

EXPRESSED Oils, such oils as are obtained from bodies by pressure.

EXPRESSION, in *Rhetoric*, the elocution, diction, or choice of words in a discourse.

Expression, in *Painting*, a natural and lively representation of the subject, or of the several objects intended to be shown. The expression consists chiefly in representing the human body and all its parts in the action suitable to it; in exhibiting the several passions proper to the figures; and in observing the motions they impress on the external parts.

EXSICCATION (formed from *ex*, and *siccus*, dry), in *Chemistry*, the act of drying up or evaporating the moisture of a thing.

EXSPIRATION, in *Physiology*, that part of respiration by which the air is expelled or driven out of the lungs.

EXTASY, a transport which suspends the functions of the senses, by the intense contemplation of some extraordinary or supernatural object.

Extasy, in *Medicine*, a species of catalepsy, when a person perfectly remembers, after the paroxysm is over, the ideas which he conceived during the time it lasted.

EXTENSION, in *Philosophy*, one of the common and essential properties of body; or that by which it possesses or occupies some part of universal space, which is called the place of that body. See Metaphysics.

EXTENSOR, an appellation given to several muscles, from their extending or stretching the parts to which they belong.

EXTENT, in *Law*, is used in a double sense. Sometimes it signifies a writ or command to the sheriff for the valuing of lands or tenements; and sometimes the act of the sheriff, or other commissioner, upon this writ.

EXTERNAL, a term of relation applied to the surface or outside of a body, or that part which appears or presents itself to the eye or touch, in contradistinction to internal.

External is also used to signify any thing that is without a man, or that is not within himself, particularly in his mind; in which sense we say, external objects, external nature, and the like.

EXTIRPATION, formed from *ex*, and *stirps*, a root, the act of pulling up or destroying a thing to the very roots. Amongst the prayers of the Roman Catholic jubilee, there is one for the extirpation of heresy.

EXTISPEX, in *Antiquity*, the person who drew presages from viewing the entrails of animals offered in sacrifice.

EXTORTION is an illegal wresting of any thing from a person, either by force, menace, or authority.

EXTRACTION, in *Chemistry* and *Pharmacy*, the operation by which essences, tinctures, and the like, are drawn from natural bodies.

Extraction, in genealogy, implies the stock or family from which a person is descended.

Extraction of Roots, in *Algebra* and *Arithmetic*, is the method of finding the roots of given numbers or quantities. See Algebra and Arithmetic.

EXTRAORDINARII, amongst the Romans, was a body of men consisting of the third part of the foreign horse and a fifth of the foot, which was separated from the rest of the forces borrowed from the confederate states with great policy and caution, in order to prevent any design which they might possibly entertain against the natural forces. A more choice body of men were drawn from among the *extraordinarii*, under the name of *ablecti*.

EXTRAORDINARY, something out of the common course.

Extraordinary *Couriers* are those sent expressly on some urgent occasion.

Extraordinary Ambassador, or envoy, is one who is sent to treat or negotiate some special and important affair, as a marriage, a treaty, confederacy, or even on occasion of some ceremony, as condolence, congratulation, and the like.

A gazette, journal, or other newspaper extraordinary, is that which is published after some notable event, containing the detail or particulars thereof.

EXTRAVAGANTES, a name given to those decretal epistles which were published from the Clementines. They were so called, because at first they were not digested or arranged with the other papal constitutions, but seemed to be as it were detached from the canon law. They continued to be called by the same name when they were afterwards inserted in the body of the canon law. The first *extravagantes* were those of John XXII. successor of Clement V. The last collection was brought down to the year 1483, and was called the *common extravagants*, notwithstanding that they were likewise incorporated with the rest of the canon law.

EXTRAVASATION, in contusions, fissures, depressions, fractures, and other accidents of the cranium, is when one or more of the blood-vessels, which are distributed in the *dura mater*, is broken or divided, by which means there is such a discharge of blood as greatly oppresses the brain, and disturbs its office, frequently bringing on violent pains, and at length death itself, unless the patient be timeously relieved.

EXTREME is applied to the last and outermost part of any thing, or that which finishes and terminates it on one side.

Extremes, in *Logic*, denote two terms of a syllogism, the predicate and subject. They are called *extremes*, from their relation to another term, which is a medium or mean between them. The predicate, as being likewise contained in the first proposition, is called the *majus extremum* or greater extreme; and the subject, as being put in the second or minor proposition, is called the *minus extremum* or lesser extreme. Thus, in the syllogism, "Man is an animal; Peter is a man; therefore Peter is an animal;" the word *animal* is the greater extreme, *Peter* the less extreme, and *man* the medium.

Extreme *and mean Proportion*, in *Geometry*, is when a line is so divided, that the whole line is to the greater segment as that segment is to the other; or, as it is expressed by Euclid, when the line is so divided that the rectangle under the whole line, and the lesser segment, is equal to the square of the greater segment.

EXTRINSIC, among metaphysicians, is taken in various senses. Sometimes it signifies that which does not belong to the essence of another; in which sense the efficient cause and end of a thing are said to be extrinsic. Sometimes it signifies that which is not contained within another; in which sense those causes are called extrinsic which introduce something into a subject from without, as when a fire introduces heat. Sometimes it signifies a thing added or applied to another; in which sense accidents and adherents are said to be extrinsic to the subjects to which they adhere. Sometimes the vision is said to be extrinsic from some form which does not exist in it, but is adjacent to it, or by some means or other without it.

EXUVIÆ, among naturalists, denote the cast off parts or coverings of animals, as the skins of serpents, caterpillars, and other insects. It is also applied to shells and other marine bodies, frequently found in the bowels of the earth.

EY, in our old writers, the same with *insula*, an island; from which comes *eyet*, a small island or islet, vulgarly called *eyght*.

EYE, in *Anatomy*. See Anatomy and Optics.

Eye, a borough town of the county of Suffolk, ninety miles from London, in the hundred of Hartismere. It is situated in a level country, and nearly surrounded with a small stream. There is a good market place, but the streets are neither wide nor well built. The greater portion of the town belonged to the late Marquis Cornwallis, but since his death has been sold to Sir Edward Kerrison. There was formerly some trade in spinning worsted, and in making inferior bone-lace; but these have been destroyed by the introduction of machinery. Two members were returned to the House of Commons, but since 1832 it sends only one. There was formerly a Benedictine monastery, the chapel of which, a fine building, is now the parish church. The market is held on Saturday. The population amounted in 1801 to 1734, in 1811 to 1893, in 1821 to 1882, and in 1831 to 2313.

EYEMOUTH, a town of Berwickshire, in Scotland, situated at the embouchure of the river Eye, from which circumstance it takes its name. Eyemouth lies seven miles from Berwick. It is a place of considerable antiquity, and enjoys the distinction of being a burgh of barony. It was at an early period of some importance; first, on account of its possessing a fort of great strength, which, however, is now destroyed; and, secondly, from the circumstance of its being the first harbour in the Scottish territory reached by vessels sailing from England, or along the English coast. On this account it no doubt must have frequently become a place of refuge and shelter to vessels, whether from hostile pursuit or storms at sea. Eyemouth still derives advantages from its harbour, which is well fitted for the reception of vessels in distress; and from it is exported a great deal of country produce. The town also possesses a distillery. The population amounted in 1821 to 1165, and in 1831 to 1181.

EYNAPOOR, a town of Hindustan, in the province of Bejapoor, belonging to the Mahrattas, twelve miles south-east from Merritch. It is of considerable size, and contains some Mahommedans, who subsist on grants of charitable lands. Long. 75. 10. E. Lat. 16. 50. N.

EYRIE, in *Falconry*, a brood or nest; also a place where hawks build and hatch their young.

EZEKIEL, a canonical book of the Old Testament, referring chiefly to the degenerate manners and corruptions of the Jews at the time when it was written. It abounds with fine sentences and rich comparisons, and discovers much learning in regard to profane matters.

Ezekiel was carried captive to Babylon with Jehoiachin, and began his prophecies in the fifth year of the captivity. He was contemporary with Jeremiah, who prophesied at the same time in Judæa, and foretold many events, particularly the destruction of the temple, the fatal catastrophe of those who revolted from Babylon to Egypt, and the happy return of the Jews to their native land.

EZETOVA, a river of Asiatic Russia, which runs into the estuary of the Oby, in long. 74. 14. E. and lat. 67. 50. N.

EZRA, a canonical book of the Old Testament, comprehending the history of the Jews from the time of Cyrus's edict for their return, till the twentieth year of Artaxerxes Longimanus. It specifies the number of Jews who returned, and Cyrus's proclamation for the rebuilding of the temple, together with the laying of its foundation, the obstruction which it met with, and the finishing of the sacred edifice in the reign of Darius.

The books of Ezra, called in the English version the *First and Second Books of Esdras*, though held by some, particularly the Greeks, as canonical, are thrown by the English church into the number of apocryphal books, as they are only extant in Greek.

F.

F, THE fourth consonant and sixth letter of the alphabet. The letter F is borrowed from the digamma or double gamma, F, of the Æolians, as is evident from the inscription on the pedestal of the Colossus at Delos; and though this letter is not found in the modern Greek alphabet, yet it was in the ancient one, whence the Latins received and transmitted it to us. It is formed by a strong expression of the breath, and joining at the same time the upper teeth and under lip. It has but one sort of sound, which has a great affinity with *v* and *ph*, the latter being written for it by us in all Greek words, as *philosophy*, though the Italians write the same term *filosofia*. The Romans for some time used an inverted F, instead of V consonant, which had no peculiar figure in their alphabet. Thus, in inscriptions we meet with TERMINAℲIT, DIℲI, and so on. Lipsius and others say, that it was the Emperor Claudius who introduced the use of the inverted digamma or Ⅎ; but it did not long subsist after his death; for Quintilian observes, that it was not used in his time. F or FA, in *Music*, is the fourth note in rising in this order of the gamut, *ut*, *re*, *mi*, *fa*. It likewise denotes one of the Greek keys in music, destined for the bass. F, in physical prescription, stands for *Fiat*, or Let it be done; thus, *f. s. a.* signifies *fiat secundum artem*. F was also a numeral letter signifying forty; according to the verse,

> Sexta quaterdenos gerit quæ distat ab alpha.

And when a dash was added at top, thus, $\bar{\text{F}}$, it signified forty thousand. In the civil law, two f's joined together thus, *ff*, signify the Pandects. In the law of England, F was a stigma or brand put upon felons (by stat. 4 Henry VII. c. 13) with a hot iron, on their being admitted to the benefit of clergy.

FABIAN, or FABYAN, ROBERT, an alderman of the city of London, and sheriff in the year 1493, was a person of some learning, a tolerable poet, and author of a Chronicle of England and France, entitled *The Concordance of Histories*, in two volumes folio, and containing several curious particulars, not elsewhere to be found, relative to the city of London. Stowe calls it "a painful labour, to the great honour of the city and of the whole realm." We are told that Cardinal Wolsey caused as many copies of this book as he could procure to be burned, because the author had made too clear a discovery of the large revenues of the clergy. Fabyan died in 1512. There have been five editions of his works, the first of which was printed by Pynson, in 1516; the second by Rastell, in 1533; the third by Reynes, in 1542; and the fourth by Kingston, in 1559, all in folio; whilst the fifth forms part of the series of Chronicles edited by Ellis, and is reprinted from Pynson's edition, with various collations and improvements.

FABII, a noble family at Rome, of Sabine origin, said to have derived its name from *faba*, a bean, because some of its ancestors had cultivated that pulse. It is a curious circumstance, to which the annals of the Roman republic afford no parallel, that for seventeen consecutive years, from 495 to 479 B. C., one of the seats in the consulship was always filled by members of this house. At this period they were firm adherents of the aristocratic party, and exerted all their influence to support their privileges; but at last, convinced of the fatal consequences that must ensue to their country from an obstinate resistance to the wishes of the great body of the nation, the Fabii changed the policy of their family, and joined the popular party. When they found themselves regarded as traitors and apostates, they came to the resolution of leaving, with their dependents and adherents, a place where they could no longer live in peace, and of founding a settlement which might at least be of use to the people whom they were so intimately allied to by blood and birth. It is in this way that we explain the fact of their being found near Veii. We may infer from Gellius (xvii. 21), that they were not merely an advanced guard, occupying a fort in the enemy's country, but that they had a settlement on the banks of the Cremera. Here the whole family was destroyed by the Veientes, 477 B. C. Only one remained to perpetuate the name, whose tender years, according to Livy, had kept him at Rome; but as he was consul ten years afterwards, we must regard this statement as purely legendary.

FABIUS PICTOR, the father of Roman history, respecting whom we know but little. In the interval between the first and second Punic wars we find him taking an active part in the subjugation of the Gauls in the north of Italy (225 B. C.); and after the battle of Cannæ (216 B. C.), he was employed by the Romans to proceed to Delphi, in order to consult the oracle of Apollo. But it is as an historian that he is entitled to our attention; as the earliest of the Roman annalists who set the example of writing the history of his country in prose. The rude muse of Nœvius had already celebrated in verse the glory acquired by the Roman arms in the first Punic war, and Ennius had clothed the annals of his adopted country in the language of poetry. The sources from which Fabius derived his history were no doubt the annals of the pontiffs, who were in the habit of noting on a tablet the remarkable events of each year, such as prodigies, eclipses, campaigns, triumphs, and the deaths of illustrious men; and these were afterwards collected into a book. This custom continued till the pontificate of P. Mucius and the times of the Gracchi. Such was the foundation for his history; and his style seems to have partaken much of the dry and jejune character of the memoirs which he copied. Polybius has expressed a doubt respecting their credibility, but, we think, without sufficient reason. That he should have copied from a Greek writer, Diocles of Alexandria, as Dionysius hints, carries with it its own refutation; but it is a curious fact that he wrote his annals in the Greek as well as Latin language. To what period he brought down his history we are unable to determine. Livy speaks of his death 169 B. C. (Molleri *Diss. de Q. Fabio Pictore*, Altorf. 1689; Lachman, *De Fontib. Livii*; Fabric. *Bibl. Lat.*)

Fabius *Maximus Verrucosus*, one of the most distinguished men whom Rome produced, the principal events of whose life are included between 233 and 203 B. C. He first makes his appearance in history as the conqueror of the Ligurians, who had long braved the power of Rome; and though we have no account of his proceedings from this period down to the beginning of the second Punic war, he must have no doubt taken a prominent part in public affairs, as he was then appointed to head the embassy (219 B. C.) sent to Carthage to inquire whether that state approved of Hannibal's proceedings in attacking Saguntum. The answer proved unsatisfactory; when Fabius, assuming the haughty dignity of a Roman senator, and folding up his cloak so as to form a cavity, thus addressed the nobles of Carthage: "Hic vobis bellum et pacem portamus; utrum placet sumite." Being answered that he might give which he pleased, he indignantly exclaimed, "Then I denounce war against you;" and the deputies returned to Rome to state the result of their mission. The disastrous campaign on the Trebia, and the defeat on the banks of the Thrasymene Lake, must have warned Rome that her successful resistance to Hannibal, and even her very existence, mainly depended on the wisdom of the general to whom she had entrusted her troops. Every thing pointed out Fabius as the person on whom the fate of Rome ought to be allowed to depend. The senate appointed him dictator; and the fearless character of Minucius probably induced Fabius to make him, as master of the horse, second in command. The proceedings of Fabius did not eventually disappoint the expectations of his countrymen. The grand object of his policy was to weary out and exhaust the army of Hannibal, without the risk of a general engagement; and so closely did he adhere to the plan which he had laid down for himself, that he received from this circumstance the name of Cunctator. His slow and cautious policy by no means suited the ardent spirit of the Romans, and more particularly that of Minucius, who began to ridicule the proceedings of Fabius, and, when he was absent at Rome, took the opportunity of attacking the enemy, and came off victorious. This tended only more strongly to confirm the opponents of Fabius in their opinion; and Varro, who was at this time exerting his utmost to acquire notoriety, was the only person who had boldness or impudence enough to propose to the people that Minucius should be made equal in command with Fabius. The result was exactly such as might have been anticipated. Minucius engaged in battle with Hannibal, and his army would have been cut to pieces, but for the opportune arrival of Fabius. Minucius seems to have had the moral courage to confess his folly, and cheerfully to submit to the orders of Fabius. At the end of six months he resigned his command.

But it was not long before Rome was again obliged to have recourse to the experience of Fabius. After the defeat at Cannæ (216 B. C.), he was appointed, along with Marcellus, to the command of the armies; Fabius being called *the shield*, and Marcellus *the sword*, of the republic. He laid siege to the important city of Capua; and when Hannibal marched towards Rome, threatening the city itself, Fabius remained firmly at his post, trusting in the known bravery of his fellow-citizens. Again, in his fifth consulship, we find him taking the city of Tarentum; and when it was proposed, towards the conclusion of the war, that Scipio should pass into Africa, Fabius was decidedly opposed to the scheme. But he did not live to witness the final success of Scipio, having died at an advanced age, 203 B. C. Plutarch has written his life; and many facts respecting him may be gathered from Livy, xxi.–xxx.

FABLE, a tale or feigned narrative, disguised under allegory, and designed both to amuse and instruct.

Fable is also used for the plot of an epic or dramatic poem; being, according to Aristotle, the principal part, and, as it were, the soul of the poem. See Poetry.

FABRIANO, Gentile da, an historical painter, was born at Verona in 1332, and became a disciple of Giovanni da Fiesole. In that early age of painting he rendered himself famous, and was employed to adorn a great number of churches and palaces at Florence, Urbino, Siena, Perugia, and Rome, but particularly in the Vatican; and one picture of his, representing the Virgin and Child, attended by Joseph, which is preserved in the church of Santa Maria Maggiore, was highly commended by Michel Angelo. By order of the doge and senate of Venice, he painted a picture in the great council chamber, which was considered as so extraordinary a performance, that his employers granted him a pension for life, and conferred upon him the highest honour of their state, namely, the privilege of wearing the habit of a noble Venetian. He died in 1412.

FABRIANO, a city of the papal delegation of Macerata, in Italy, on the river Giano. It is the seat of a bishop, has nine monasteries, nine nunneries, and 7224 inhabitants, who are occupied in making paper and preparing parchment. The paper made here is celebrated throughout Italy.

FABRICIUS, George, a Latin poet and historian, was born at Kemnitz, in Germany, on the 24th April 1516. He began his studies in his native place, and completed them at Freyberg and at Leipsic, where he was preceptor to Wolfgang, and also to Philip and Antony Werter. He travelled into Italy with the elder of his pupils, and on his return to Germany in 1553, was appointed director of the college of Meissen, where he died on the 13th July 1571. In his poetical compositions, which obtained for their author considerable distinction, he affected not to employ any word which had the slightest flavour of paganism; and he blamed those poets who had in their works introduced the pagan divinities. All that he wrote on the history of his country is, in the judgment of Niceron, estimable for research and accuracy; and Lenglet Dufresnoy pronounces a similar opinion. The following list includes the principal works which he published, either as author or as editor: 1. *Terentii Afri Comœdiæ sex cum castigatione duplici Joannis Rivii et G. Fabricii*, Strasburg, 1548, in 8vo; 2. *Roma, sive Liber utilissimus de veteris Romæ situ, regionibus, viis, templis, aliisque ædificiis*, Bâle, 1550, in 8vo; 3. *Virgilii Opera cum commentariis Servii et T. C. Donati*, Bâle, 1551, in fol.; 4. *Virgilii Opera a Fabricio castigata*, Leipsic, 1551, 1591, in 8vo; 5. *Poëmatum Sacrorum libri quindecim*, Bâle, 1560, in 16to; 6. *Poematum veterum ecclesiasticorum opera Christiana et operum reliquiæ ac fragmenta*, 1562, in 4to; 7. *De Re Poëtica libri septem*, 1566, in 8vo; 8. *Rerum Misnicarum libri septem*, 1569, in 4to; 9. *Originum illustrissimæ stirpis Saxonicæ*

Fabricius.

libri septem, 1597, in fol.; 10. *Rerum Germaniæ magnæ et Saxoniæ universæ memorabilium volumina duo*, Leipsic, 1609, in fol.

Fabricius, or *Fabrizio, Jerome*, surnamed *Acquapendente*, from his having been a native of the episcopal city of that name, in Italy, where he was born in 1537. His parents, though poor, were desirous to give their son an excellent education, and with this view sent him to Padua, where the young Fabricius soon found powerful protectors to assist in the cultivation of his talents. After completing his course of philosophy, he applied himself to medicine, which he studied under the celebrated Fallopius, and soon became the most distinguished pupil of that learned professor, whom he afterwards succeeded. Fallopius having died in 1562, Fabricius, then only twenty-five years of age, was at first employed merely to give anatomical demonstrations; but he discharged this duty with so much zeal and ability that, in 1565, he was formally promoted to the chair of surgery, whilst that of anatomy, which had hitherto been considered as merely a dependence or accessory of the other, was declared primary in favour of Fabricius, to whom were also assigned very considerable appointments. And to these preferments the senators of Venice added the highest distinctions which it was in their power to bestow. They granted him privileges not less extraordinary than flattering, gave him precedence of the professors of philosophy, named him citizen of Padua, honoured him with a statue and a gold chain, decorated him with the order of knight of St Mark, constructed a superb anatomical theatre for his accommodation, and assigned him a liberal retired allowance, with the right of naming his successor. Fabricius practised his profession with much dignity and with rare disinterestedness. Persons of high rank, who were indebted to him for the re-establishment of their health, made up by rich presents for the fees which the generous physician refused; and these Fabricius collected in a cabinet, on the door of which he caused to be inscribed the words *Lucri neglecti lucrum*. He possessed a beautiful country-house, situated on the delightful banks of the Brenta, and still known by the name of *Montagnuola d'Acquapendente*, where, sound in body and mind, loaded with riches, generally esteemed, and enjoying a brilliant reputation, he calculated on spending a happy old age. But his expectations were cruelly disappointed, and his repose was disturbed by envy and ingratitude. It is even said that he was sometimes obliged to employ the knife for other purposes than surgical operations and dissections. Relations on whom he had never ceased to lavish favours, unworthily betrayed his confidence, and are suspected, not without reason, of having abridged his days by means of poison. Having attained the age of eighty-two, he died suddenly in an agony of vomiting, on the 21st May 1619, leaving to his niece a fortune of two hundred thousand ducats, and to the republic of letters the following works, which are much esteemed: 1. *De Visione, Voce, Auditu*, Venice, 1600, in fol.; 2. *De formato Fœtu liber*, Venice, 1600, in fol.; 3. *De Venarum ostiolis*, Padua, 1603, in fol.; 4. *De Locutione et ejus instrumentis*, Venice, 1603, in 4to; 5. *De Brutorum loquela*, Padua, 1603, in fol.; 6. *De Musculi artificio ac Ossium dearticulationibus*, Vicenza, 1614, in 4to; 7. *De Motu locali Animalium secundum totum*, Padua, 1618, in 4to; 8. *De Respiratione et ejus Instrumentis libri duo*, Padua, 1615, in 4to; 9. *De Gula, Ventriculo, Intestinis*, Padua, 1618, in 4to; and also, *De totius Animalis integumentis*, Padua, 1618, in 4to. These different fragments were collected and printed by Bohn, with a preface, under the title of *Opera omnia Anatomica et Physiologica, hactenus variis locis ac formis edita, nunc vero certo ordine digesta, et in unum volumen redacta*, Leipsic, 1687, in fol. But the Leyden edition, published in 1738, by Bernard-Lifroy Albinus, is preferred to that of Bohn, as containing a life of the author, and the prefaces of the different treatises, which Bohn had unaccountably suppressed. All the writings of Fabricius are truly classical, and fully justify the high reputation of their author. His style is pure, and even elegant; the language of Hippocrates was as familiar to him as that of Celsus; and lucid order pervades all his writings. In regularity of plan and clear luminous method he is unsurpassed. "On a reproché à ce grand chirurgien trop de timidité dans l'exercice de son art, et pourtant nous le voyons," says his French biographer, "pratiquer et perfectionner le trépan, employer avec autant de hardiesse que de talent le bistouri, l'aiguille, le trois-quarts, la rugine et même le fer rouge, quoiqu' en dise Severino. Haller, qui, certes, ne le juge pas avec bienveillance, est forcé de lui rendre justice sur ces divers points." In a word, Fabricius was one of the greatest ornaments of the university of Padua, and one of the most celebrated anatomists and surgeons of the sixteenth century. (A.)

Fabricius, *John Albert*, one of the most learned, laborious, and useful of bibliographers, was born at Leipsic on the 11th of November 1668. He lost his mother in 1674, and five years afterwards his father, Werner Fabricius, director of music in the church of St Paul at Leipsic, and author of several works, particularly *Deliciæ Harmonicæ*, published in 1657. The subject of this notice commenced his studies under his father, who, on his deathbed, recommended him to the care of Valentine Alberti. He studied during five years under Wencelaz Buhl, then for some time under J. S. Herrichen; and, in 1684, he was sent to Quedlinburg, there to continue his studies under Samuel Schmidt. From this period the *Adversaria* of Barthius formed his delight; and when, in 1687, he saw the first volume of Morhof's *Polyhistor*, the desire which he had already felt of devoting himself to letters greatly increased. Having returned to Leipsic in 1686, he was the same year admitted bachelor in philosophy, and, in the beginning of 1688, he took the degree of master in the same faculty; soon after which he published his first work, consisting of only one sheet in quarto. He then applied himself to the study of medicine, which, however, he relinquished for that of theology; and having gone to Hamburg in 1693, he proposed to travel into several countries, when the unexpected and not very agreeable information which now reached him, that the expense of his education had absorbed his whole patrimony, and even left him in debt to his trustee, forced him to abandon his project. He therefore remained at Hamburg, where J. F. Mayer employed him in the capacity of librarian. In 1696 he accompanied his patron to Sweden, and, on his return to Hamburg, not long afterwards, he competed for the chair of logic and philosophy. The suffrages being equally divided between Fabricius and Sebastian Edzardi, one of his opponents, recourse was had to chance, which decided in favour of Edzardi; but in 1699 Fabricius succeeded Vincent Placcius in the chair of eloquence and practical philosophy, after which he took the degree of doctor in theology at Kiel. From 1692 to 1697 he had preached regularly every Friday; but after he received his appointment of professor, he devoted the greater part of his time to the duties of that office. In 1701, J. F. Mayer having established himself at Greifswald, caused the chair of theology in that city to be offered to Fabricius, who, however, refused it on account of his health. But in 1708 he had accepted the situation of professor of theology, logic, and metaphysics, and was preparing to enter on his new office, when the senate of Hamburg induced him to remain, by adding to his charge as professor that of rector of the school of St John, then held by his father-in-law, Schultz, whom Fabricius was very willing to assist in the discharge of his duties. Schultz died in 1709, but Fabricius retained the rectorship two years longer. In 1719 the landgrave of Hesse Cassel made him so advantageous an offer, that Fabricius was on the point of accepting it; but this time also the magistrates, by a seasonable increase of salary, prevailed on him to remain amongst them. An attempt was subsequently made to draw him to Wittenberg. But Fabricius refused to listen to the proposals which were made to him, and died at Hamburg on the 30th of April 1736. Besides the time which he had devoted to the duties of his office, Fabricius spent a considerable portion in maintaining an extensive correspondence, and in receiving the visits of foreigners; but he was so laborious that he was nevertheless the author of a great number of works, the list of which, according to Niceron and Reimar, includes as many as a hundred and twenty-eight. It will be sufficient here, however, to indicate the most remarkable of these, which are, 1. *Scriptorum recentium Decas*, Hamburg, 1688, in 4to; 2. *Decas Decadum, sive Plagiariorum et Pseudonymorum centuria*, 1689, in 4to; 3. *Bibliotheca Latina, sive notitia Auctorum veterum Latinorum quorumcunque scripta ad nos pervenerunt*, Hamburg, 1697, in 8vo, a work which was republished in an improved and amended form by J. A. Ernesti, Leipsic, 1773, in 3 vols. 8vo; 4. *Bibliotheca Græca, sive notitia Scriptorum veterum Græcorum quorumcunque monumenta integra aut fragmenta edita extant, tum plerorumque e manuscript. ac deperditis*, Hamburg, 1705–1728, in 14 vols. 4to, a work which has justly been denominated *maximus antiquæ eruditionis thesaurus*; 5. *Centuria Fabriciorum scriptis clarorum qui jam diem suum obierunt*, 1705, in 8vo, and a second Century in 1727; 6. *Bibliotheca Antiquaria, sive Introductio in notitiam Scriptorum qui antiquitates Hebraicas, Græcas, Romanas, et Christianas scriptis illustrarunt*, 1713 and 1726, in 4to; 7. *Centifolium Lutheranum, sive notitia literaria Scriptorum omnis generis de B. D. Luthero*, 1728 and 1730, in 8vo; 8. *Conspectus Thesauri Litterarii in Italia, præmissam habens præter alia notitiam Diariorum Italiæ litterariorum thesaurorumque ac corporum historicorum et academiarum*, 1730, in 8vo; 9. *Delectus argumentorum et syllabus Scriptorum qui veritatem religionis Christianæ adversus atheos, epicureos, deistas seu naturalistas, idolatras, Judæos et Muhammedanos lucubrationibus suis asseruerunt*, 1721, in 4to; 10. *Salutaris lux Evangelii toti orbi per divinam gratiam exoriens, sive notitia historico-chronologica, litteraria ac geographica propagatorum per orbem totum Christianorum sacrorum*, 1731, in 4to; 11. *Hydrotheology*, in German, 1734, in 4to; 12. *Bibliotheca Latina mediæ et infimæ Latinitatis*, 1734–1756, in 5 vols. 8vo. The principal works edited by Fabricius were, 1. *Vincentii Placcii theatrum anonymorum et pseudonymorum*, Hamburg, in two vols. fol.; 2. *Joannis Mabillonii iter Germanicum, et Joannis Launoii de Scholis celebribus a Carolo Magno et post Carolum Magnum in occidente instauratis liber*, 1717, in 8vo; 3. *Anselmi Bandurii Bibliotheca Nummaria*, 1719, in 4to; 4. *Danielis Georgii Morhofii Polyhistor litterarius, philosophicus, ac practicus, cum accessionibus Joannis Frikii et Joannis Molleri*, 1732, in two vols. 4to; 5. *Bibliotheca Ecclesiastica*, 1718, in fol.; 6. *Codex apocryphus Novi Testamenti collectus, castigatus, testimoniisque, censuris et animadversionibus illustratus*, 1703, in two vols. 8vo; 7. *Codex pseudepigraphus Veteris Testamenti collectus, castigatus, testimoniisque, censuris et animadversionibus illustratus*, 1713 and 1722, in two vols. 8vo.

Fabricius, *Vincent*, born at Hamburg on the 13th of September 1612, studied at Leyden, and there took his degrees in medicine in 1634. He had already made himself known by his talent for Latin poetry; and two years before this, had published a collection of verses, at the solicitation of his friend and patron Daniel Heinsius. He then applied himself to the study of law, in which his progress was not less rapid than it had been in the other sciences, and in due time he became a learned civilian. The bishop of Lubec conferred on him the title of counsellor, with suitable appointments; but he did not hold this situation for any length of time; and having established himself with his family at Dantzic, he was soon afterwards named syndic, and then burgomaster, of that city. The knowledge which he had acquired of the interests of the republic, and the talent for public speaking which he displayed upon occasions of importance, caused him to be thirteen times returned by the senate as their deputy to the Polish diet. He died at Warsaw, during one of the sessions of that body, on the 11th September 1667. The first edition of the poems of Fabricius appeared at Leyden in 1632; and the second, corrected and augmented by the author, in 1638. But his son, Frederic Fabricius, published a third at Leipsic, 1685, in 8vo, containing several pieces which had been omitted in the preceding editions, besides the *Harangues* pronounced by him in the Polish diet, a discourse *De Obsidione et Liberatione urbis Leidensis*, delivered at Leyden in 1632, and the medical theses maintained by him in the same city.

Fabricius, *John-Christian*, the most celebrated entomologist of the eighteenth century, was born at Tundern, in the duchy of Sleswick, in 1742. After having completed his studies, at the age of twenty, he repaired to the university of Upsal, to attend the prelections of Linnæus. How long he remained there is uncertain. But no pupil was ever more indebted to the lessons of his master than Fabricius. All his works on entomology, which have secured to him a well-merited reputation, indicate the precepts, the method, and even the forms of Linnæus, applied to the development of a single new idea, not more fortunate in conception than fruitful in its consequences. Far from disguising the obligations which he owed to his master, Fabricius delighted to expatiate on the happy moments which he had passed in the society of Linnæus; and the grateful scholar has transmitted to us those biographical details, which are not only the most interesting in themselves, but at the same time best fitted to give us an insight into the character of the great naturalist. It was in studying under the latter that Fabricius conceived the idea of his system, and formed the project of his labours on insects. The first insect's mouth which he dissected was that of a cockchafer (*scarabæus stridulus*); he showed it to Linnæus, with the description he had made of it, and proposed to him to employ the organs of the mouth, in order to establish the characters of insects, in the new edition of the *Systema Naturæ* which Linnæus was then preparing. The latter encouraged his pupil to pursue this course, but refused to enter on it himself, because, as he said, he was too old to change his method. Forced to choose a profession, Fabricius studied medicine, and at the age of twenty-five took the degree of doctor in physic; but being soon afterwards appointed professor of natural history in the university of Kiel, he devoted himself entirely to his favourite pursuits, and, in 1775, published his system of entomology. This work gave a new aspect to the science. Swammerdam and Ray had classed insects according to their metamorphoses; Lister, Linnæus, and Geoffroy, according to the organs of motion; and some entomologists, as Reaumur, Scopoli, and even Linnæus himself, had employed the nutritive organs in order to characterize distinctively certain genera. But before the time of Fabricius no one had thought of making these the basis of a general classification. This idea was at once new and bold, and the author evolved it with singular ability. In a second work, which he published two years afterwards, he developed the characters of the classes and genera, showing in the preface the advantages of his method, and, at the same time, excusing its inconveniences. Lastly, in 1778, he published *Entomological Philosophy*, in imitation of the *Botanical Philosophy* of Linnæus; and from this period till his death, that is, during the space of more than thirty years, he was incessantly occupied in extending his system, which he reproduced under different forms in the various works which, from time to time, he gave to the world. But in proportion as the number of species increased, the characters of the *genera*, and even of the classes, became more and more uncertain and arbitrary; and, with reference to this fundamental point, his later writings are perhaps inferior to those which preceded them. The basis which he had assumed was excellent; but it could only conduct him to a *natural method*, not, as he supposed, to a *system;* and this misconception led him to neglect other considerations which would have furnished more exact means of classification. Fabricius had a very extensive knowledge of botany, and of the other branches of natural history. He had been appointed counsellor of state to the king of Denmark, and professor of rural and political economy, in which capacity he published, in German and in Danish, several useful works, though much less celebrated than those which appeared from his pen on the subject of entomology. Fabricius died in 1807, at the age of sixty-five, of a melancholic affection, produced, as is alleged, by the bombardment of Copenhagen. The following is a list of his works: 1. *Systema Entomologiæ*, Flensburg, 1775, in 8vo; 2. *Genera Insectorum*, Kiel, 1776, in 8vo; 3. *Philosophia Entomologica*, Hamburg, 1778, in 8vo; 4. *Species Insectorum*, ibid. 1778, in two vols. 8vo; 5. *Mantissa Insectorum*, Copenhagen, 1787, in 2 vols. 8vo; 6. *Nova Insectorum Genera*, in Mem. of the Soc. of Nat. Hist. Copenhagen; 7. *Entomologia Systematica*, Copenhagen, 1792–1796, in 7 vols. 8vo; 8. *Snpplementum Entomologiæ Systematicæ*, ibid. 1798, in 8vo; 9. *Systema Eleutheratorum*, Kiel, 1801, in 2 vols. 8vo, with an index; 10. *Systema Rhyngotorum*, Brunswick, 1803, in 8vo; 11. *Systema Piezatorum*, ibid. 1804, in 8vo; 12. *Systema Antliatorum*, ibid. 1805, in 8vo; 13. Description of the *Tipnla Sericea* in the Berlin Mem. tome v.; 14. *De Systematibus Entomologicis*, in the same collection; 15. *Considérations sur l'ordre général de la Nature*, Hamburg, 1781, in 8vo; 16. *Traité de la Culture des Plantes à l'usage des cultivateurs;* 17. *Observations sur l'engourdissement des Animaux durant l'hiver*, inserted in the *Mag. de Physique*, tom. ix. p. 79; 18. *Résultat des Leçons sur l'Histoire Naturelle*, Kiel, 1804, in 8vo; 19. *Sur l'accroissement de la Population, particulièrement en Danemark;* 20. *Eléments d'Economie Politique a l'usage des étudiants*, Flensburg, 1775, in 8vo; 21. *Renseignements Historiques sur le Commerce du Danemark;* 22. *Hvori bestaaer Borgendyd besvaret;* In what consists civic virtue? Copenhagen, 1786, in 8vo; 23. *Sur les Finances et la Dette en Danemark;* 24. *Recueil d'Ecrits sur l'Administration*, Kiel, 1786 and 1790, in 2 vols. 8vo; 25. *Sur les Académies, particulièrement en Danemark*, Copenhagen, 1796, in 8vo; 26. *Voyage en Norwège*, Hamburg, 1799, in 8vo; 27. *Lettres sur Londres*, Leipsic, 1784, in 8vo; 28. *Lettres au sujet d'un voyage fait en Russie;* 29. *Remarques Minéralogiques et Technologiques;* 30. *Remarques sur le Danemark*, written in English, and published by Pinkerton in his *Modern Geography*, 1807.

FABROT, Charles-Annibal, one of the most celebrated jurisconsults of his time, was born in 1580, at Aix in Provence, whither his father, originally of Nismes, had gone to establish himself during the civil wars. His early studies were successfully prosecuted, and he made great progress in the ancient languages and in the civil and the canon law. In 1606 he took the degree of doctor, and was soon afterwards admitted as advocate before the parliament of Aix. As this court then reckoned amongst its members men of distinguished merit, such as the celebrated Peiresc and William Duvair, who was its first president, their common taste for letters naturally united them with Fabrot, for whom, in 1609, Duvair procured a professorship in the university of Aix. Having become keeper of the seals, the latter carried his young friend with him to Paris, where Fabrot remained until after the death of his benefactor, when he returned to resume his peaceful functions as professor. But these did not absorb the whole of his time, and he employed his leisure in other labours, which, however, had all a relation to jurisprudence. The great interpreters whom the sixteenth century produced had left almost nothing to be added in regard to the books of this science written in Latin. But Fabrot opened for himself a different path. The successors of Justinian on the throne of Constantinople had caused to be executed in Greek an abridgment of his compilations, to which were added articles taken from the fathers and the councils; and to this abridgment Leo the Philosopher gave the name of *Basilica*, which, in fact, formed the code of the eastern empire until its destruction. The *Basilica*, long unknown, were in some sort discovered by Cujas, who made great use of them in his writings, but did not publish them. Fabrot, however, undertook this task, and, about 1639, extracted from this collection, and published in Greek and Latin, fourteen laws, which are wanting in the Digest. These, with some other productions of Fabrot, were inserted by Everard Otton in his *Thesaurus Juris Civilis*. Of the sixty books of which the *Basilica* were composed, thirteen have been lost. Those which remain Fabrot translated; and he supplied, by means of summaries, the place of those which are lost. This work, consisting of seven volumes in folio, was published in 1647 at Paris, where Fabrot had now established himself, and was dedicated to the Chancellor Seguier, through whose influence, exerted in his favour, he obtained a considerable pension, by means of which he was enabled to continue his useful labours. Matthieu Molé, at first procureur-général, then first president and keeper of the seals, a man whose heroic firmness is so well known, and Jerome Bignon, a magistrate distinguished for his knowledge and integrity, likewise gave Fabrot proofs of the estimation in which they held his talents. Besides the *Basilica*, the latter also translated into Latin the Greek paraphrase which Theophilus had made of the *Institutions* of Justinian (Paris, 1638 and 1657, in 4to). The particular nature of his pursuits having rendered him familiar with the Byzantine historians, Fabrot published several of their works, such as those of Cedrenus, Nicetas, Anastasius the Librarian, and others, enriched with notes and dissertations. And as he was not only acquainted with the civil, but also with the canon law of the lower empire, which in fact form but one whole; when Justel and William Voet compiled their Library of Canon Law, which appeared in 1661, they inserted in that compilation the constitutions of Theodorus Balsamon, which were found amongst the papers of Fabrot, with notes in his peculiar manner. But one of the undertakings which have done the greatest honour to this learned jurisconsult, is his edition of the works of Cujas, which he corrected according to several manuscripts, and enriched with notes and several treatises of Cujas, which had not previously seen the light. Before the appearance of those of Naples and of Venice, this was the best of all the editions of Cujas. Fabrot commenced it in 1652, and completed it in 1658. It is believed that the continued and intense application which he bestowed on this work caused the malady of which he died on the 16th of January 1659. His reputation was so extensive, that the most celebrated universities of France desired to have the benefit of his services as professor of law; but he refused every offer of the kind which was made to him, however advantageous, that his attention might not be diverted from the great undertakings in which he had embarked. Fabrot wrote, 1. *Epistola de Mutuo cum responsione Cl. Salmasii ad Menagium*, Leyden, 1645, in 8vo; 2. *Les Antiquités de la Ville de Marseille*, translated from the Latin of J. Raymond de Solier, Marseilles, 1615, and Lyons, 1632, in 8vo; 3. *Exercitationes duæ de tempore partûs humani et de numero puerperii*, Aix, 1629, in 4to; 4. *Prælectio in titulum Decretalium "De vita et honestate Clericorum,"* Paris, 1651, in 4to; 5. *Notæ at titulum Codicis Theodosiani "De paganis sacrificiis et templis,"* Paris, 1648, in 4to.

FABULOUS, something consisting of or connected with fable.

FACATA, or Fucata, a seaport of Japan, in the island of Ximo, where the Jesuits formerly had a considerable establishment and a church. It is twenty-seven miles west-north-west of Taisero.

FACE, the surface or first side which a body presents to the eye. Thus, we say, the *face* of the earth, of the waters, and the like; polyhedrons have several *faces;* a die or cube has six *faces.*

Face is particularly used for the visage of an animal, especially of man, and comprehends, in the latter, all that part of the head which is not covered with long hair. The Latins call it *facies, vultus, os.*

FACIES Hippocratica, in *Medicine*, is when the nostrils are sharp, the eyes hollow, the temples low, the tips of the ears contracted and cold, the forehead dry and wrinkled, and the complexion pale or livid. The Hippocratic face is chiefly observed towards the close of phthisis pulmonalis, and other consumptions, and is held as a sure prognostic of death. If it appear within three days after the attack of an acute disease, it is deemed a fatal symptom.

FACTION, a cabal or party formed in a state, city, or company.

Faction, in *Antiquity*, a name given to the different companies of combatants in the circus. They were four in all; the white, the red, the green, and the blue, to which Domitian added another of purple colour. They were so denominated from the colour of the liveries they wore, and were dedicated to the four seasons of the year; the green being consecrated to spring, the blue to winter, the red to summer, and the white to autumn. It appears from ancient inscriptions, that each faction had its procurators and physician; and that party rage ran so high amongst them, that in a dissension between two factions, in the time of Justinian, nearly forty thousand men lost their lives.

FACTITIOUS, any thing made by art, in opposition to that which is the production of nature. Thus, factitious cinnabar is opposed to native cinnabar.

FACTOR, in *Commerce*, is an agent employed by merchants residing at other places, to buy or sell goods, negotiate bills, or transact any kind of business on their account, and entitled to a certain allowance for his trouble.

A supercargo differs from a factor in this, that the business of the former is limited to the care of a particular cargo; he goes along with it, and generally returns when his business is completed; whereas the latter has a fixed residence abroad, and executes business for different merchants.

Factor, in *Multiplication*, a name given to the multiplier and multiplicand, because they constitute the product.

FACTORAGE, called also *commission*, is the allowance given to factors by the merchant who employs them.

FACTORY is a place where a considerable number of factors reside, in order to negotiate for their masters or employers.

FACULÆ, in *Astronomy*, certain bright and shining parts, which the modern astronomers have, by means of telescopes, observed on the surface or disc of the sun. The word is Latin, being a diminutive of *fax*, a torch, and supposed, in this case, to be applied from these spots appearing and disappearing by turns.

FACULTY, in *Law*, a privilege granted to a person, by favour and indulgence, of doing that which by law he ought not to do.

Faculty, in the schools, a term applied to the different members of an university, divided according to the arts and sciences taught there. Thus, in most universities there are four faculties; that of arts, which includes humanity and philosophy; that of theology; that of medicine; and that of law.

FAENZA, a city of Italy, in the delegation of Ravenna, in the papal dominions. It is situated on a plain watered by the river Lamona, from which a canal is formed to join the Po Primero. It contains, besides a cathedral, twenty-eight churches, eight monasteries, and eight nunneries, with 14,000 inhabitants, who are employed in silk and other manufactures. At this place the invention of porcelain was introduced; and hence, in most of the languages of Europe, that commodity has obtained the name of the city. It was the birth-place of the celebrated Torricelli, the disciple of Galileo. Long. 11. 36. E. Lat. 44. 21. N.

FAERNUS, Gabriel, a celebrated modern Latin poet, was a native of Cremona, and flourished during the sixteenth century. He was so eminently skilled in all parts of polite literature, that the Cardinal de' Medicis, afterwards Pope Pius IV. held him in high estimation. He was the author of some Latin elegies, of a hundred Latin fables in iambic verse, selected from the ancients, and of several pieces of criticism. He was also remarkably dexterous in deciphering manuscripts, and in restoring ancient authors; and he took such pains with Terence, that Bentley has adopted all his notes in the edition which he published of that dramatist. Faernus died at Rome in 1561; and De Thou, who wrote his eulogy, says that the learned world was greatly indebted to him, and would have been still more so, if, instead of suppressing the then unknown fables of Phædrus, from fear of lessening the value of his own Latin fables, written in imitation of Æsop, he had been content with imitating them. Perrault, however, who translated the fables of Faernus into French, has defended him from this imputation, by showing that the first manuscript of Phædrus's fables, found in the dust of an old library, was not discovered till about thirty years after the death of Faernus. In fact, Plautus and Terence were his models; and the merit of his elegant style is enhanced by the circumstance that he was not an imitator of Phædrus, whom it has been satisfactorily shown he did not know. His fables, immediately upon their appearance, obtained universal applause, and were reprinted at Cologne, at Antwerp, and at Brussels. Faernus also wrote, 1. Two *Books of Corrections* on the philippics and three other speeches of Cicero, from a manuscript which had been discovered in the Vatican Library, and which he regarded as the most ancient of all those that existed of the works of Cicero; and, 2. *Notes* on Catullus and Plautus, and a *Commentary* on Terence, which was printed by

Pietro Vettori, Florence, 1567, in 8vo, and reprinted at Paris, 1602, in 4to.

FAGGOT, in the times of persecution, was a badge worn on the sleeve of the upper garment, by such persons as had recanted or abjured what was then termed heresy. It was put on after the person had carried a faggot, by way of penance, to some appointed place of solemnity. Leaving off wearing this badge was sometimes interpreted as a sign of apostasy.

FAGGOTS, amongst military men, persons hired by officers, whose companies were not full, to muster and conceal the deficiencies of such companies. This disgraceful practice has long ceased in our army.

FAID, or FEID, a town of Arabia, in the province of Nedsjed, 140 miles north-east of Hagiar. Long. 40. 36. E. Lat. 26. 54. N.

FAIFO, or HAIFO, a town of Cochin-China, situated about ten miles from the sea, on a navigable river, which flows into the bay of Huron. It was at one time a place of some importance, the streets being regular, and the houses built of brick. But it was destroyed in the course of the revolutions which befel the country; and its prosperity is now only reviving. Long. 108. 10. E. Lat. 15. 50. N.

FAILSWORTH, a township of the county of Lancaster, within the parish of Manchester, inhabited chiefly by manufacturers of cotton goods, whose numbers amounted in 1801 to 2622, in 1811 to 2875, in 1821 to 3358, and in 1831 to 3667.

FAINT ACTION, in *Law*, a feigned action, or such as, although the words of the writ are true, yet, for certain causes, the plaintiff has no title to recover thereby.

FAIRS AND MARKETS. The intimate alliance which subsists between these institutions renders it as necessary as it is convenient to treat of them together. As the term is now generally understood, a fair is just a greater species of market, but the periodical recurrence is less frequent. Both are appropriated to the sale of one or more kinds of goods, the hiring of servants, labourers, &c. In most cases, however, fairs are more numerously attended than markets, and are generally characterized by various exhibitions got up for the amusement of the people.

The following account of the origin of fairs is given by Mr M'Culloch, in his *Dictionary of Commerce.* "Institutions of this sort are peculiarly serviceable in the earlier stages of society, and in rude and inland countries. The number of shops, and the commodities in them, are then either comparatively limited, or they are but little frequented by dealers; so that it is for the advantage of all that fairs should be established, and merchants induced to attend them. For this purpose various privileges have been annexed to fairs, and numerous facilities afforded to the disposal of property in them. To give them a greater degree of solemnity, they were originally, both in the ancient and modern world, associated with religious festivals. In most places, indeed, they are still held on the same day with the wake or feast of the saint to whom the church is dedicated; and, till the practice was prohibited, it was customary, in England, to hold them in churchyards. (*Jacob's Law Dict.* art. *Fair.*) But since the growth of towns, and the opportunities afforded for the disposal and purchase of all sorts of produce at the weekly or monthly markets held in them, the utility of fairs, in this country at least, has very much diminished; they have also lost much of their ancient splendour; and, though some of them are still well attended, and of real use, a good number might be advantageously suppressed.

"But it is far otherwise in inland countries, where the facilities for carrying on commercial transactions are comparatively circumscribed. There it is of the utmost importance, that certain convenient places and specified periods should be appointed for the bringing together of commodities and dealers. This is not only the readiest and best means of promoting commerce, but also of softening national antipathies, and diffusing a knowledge of the products, arts, and customs of other countries."

In England the right of holding a fair must be derived from the crown, and, in the grant obtained, provision is made that no other fair shall be injured by the one to be established. The times of holding the fairs are determined by the letters-patent appointing the fair or market, or by usage; and penalties are imposed if they are held beyond the time specified. A *bona fide* sale made in a fair or open market, in general transfers the complete property of the thing sold to the vender, so that, however vicious or illegal the title of the vender may be, the vendee's is good against every one except the king. But the sale, in order to come within this rule, must be made on the market day, and at the place assigned for the market. Formerly the mayor or steward presided at a court called the court of *pié poudre*, in allusion to the dusty feet of the suitors, where questions as to contracts, &c. were decided; but these courts are now entirely set aside. Still, as of old, however, there is a clerk appointed, whose duty it is to see that every thing is sold according to just weights and measures. There is generally a toll attached to fairs and markets, which is paid by the buyer after the thing brought to the market has been sold.

British Fairs. Amongst these may be specified that of Stourbridge, in Worcestershire. Bristol has two considerable fairs, one in March and one in September. Exeter December fair is for cattle, horses, and most sorts of commodities. Weyhill fair, in Hampshire (October 10), has probably the greatest display of sheep of any fair in the kingdom. Bartholomew fair, in London, used to be of considerable importance, but is now appropriated only to shows of wild beasts, and such like exhibitions, and might be suppressed with advantage. St Faith's, near Norwich (October 17), is the principal English fair for Scotch cattle. They are sold to the graziers and feeders of Norfolk, Suffolk, Essex, and other counties, by whom they are fattened for the London markets, where they are met with in great abundance. But besides those sold at St Faith's, large numbers of Scotch cattle are disposed of at Market Harborough, Carlisle, Ormskirk, and other places. Ipswich has two considerable fairs; one in August, for lambs, and one in September, for butter and cheese; and it is reckoned that above 100,000 lambs are annually sold at the former. Woodborough-hill, in Dorset, is for west-country manufactures, as kerseys, druggets, &c.; and Woodstock October fair, for cheese. Northampton and Nottingham have each several large fairs, for horses, cattle, cheese, &c. The August fair of Horncastle, in Lincolnshire, is the largest horse fair in the kingdom, many thousand horses being exhibited for sale during its continuance; and it is resorted to by crowds of dealers from all parts of Great Britain, by several from the Continent, and sometimes even from North America. Howden, in Yorkshire, has also a very large horse fair, particularly for Yorkshire hunters. Devizes, in Wiltshire, has several large fairs for sheep and cattle. There is usually a large display of cheese at the Gloucester April fair. A guild, or jubilee, commencing the last week of August, is held every twentieth year at Preston, in Lancashire; the last was held in 1822, and was well attended. The October fair of Market Harborough, Leicestershire, lasts nine days, and a great deal of business is usually done in cattle, cheese, &c. Woodbridge Lady-day fair is celebrated for the show of Suffolk horses. Falkirk fair, or tryst, is one of the most important in Scotland, for the sale of cattle and sheep. The October fair of Ballinasloe, in the county of Galway, is famous for the display of cattle and sheep;

and by far the largest proportion of these animals raised for sale in Connaught being disposed of at it.

French Fairs. The principal French fairs are those of St Germains, Lyons, Rheims, Chartres, Rouen, Bordeaux, Troyes, Bayonne, and Beaucaire, but they are said to be for the most part much fallen off, although that which was held in 1833, at the last-named place, was the greatest which had taken place for many years.

German Fairs. The principal German, or rather European fairs, are those of Frankfort on the Maine, Frankfort on the Oder, and Leipsic. The business transacted at these fairs is in general very great. Merchants of all nations are there assembled, for disposing of the manufactures, merchandise, and productions, for which their several countries are distinguished. Frankfort on the Maine has two, and Frankfort on the Oder three fairs yearly. Leipsic has also three annual fairs, and these are by far the most celebrated. They are held on the first of January, at Easter, and at Michaelmas. The first is the least important. The two latter, particularly the former, are remarkable for the vast number of new publications usually offered for sale. They are attended by all the principal booksellers of Germany, and by many from the adjoining countries, who adjust their accounts, learn the state of the trade in all parts of the world, and endeavour to form new connections. Most German publishers have agents in Leipsic, which is to the literature of Germany what London is to that of Great Britain. As many as four thousand new publications have been in a single Leipsic catalogue. The fairs ought to close in eight days, but they usually continue for about three weeks.

Italian Fairs. Of these, the most celebrated is that of Sinigaglia, on the Misa. It commences on the 14th of July, and continues for about twenty days. Here, as at the German fairs, are assembled merchants from almost all nations.

Russian Fairs. These are numerous, and many of them are well attended. The most important is held at Nishnei-Novogorod, a city situated at the confluence of the Oka with the Wolga. It is the great emporium of the internal trade of Russia. The fair generally lasts from six weeks to two months, and is well known all over the east of Europe. In point of value this fair is considered as second to none in Europe. Another celebrated Russian fair is that of Kiachta, on the Chinese frontier. At this fair by far the largest part of the commerce between the Russian and Chinese empires is transacted. The goods disposed of are principally the products of the respective countries.

Eastern Fairs. The most important fair in the eastern world is that held at Mecca, during the resort of pilgrims in the month of Dhalhajja. It has declined of late years, but the concourse which attends it is still very great. The greatest fair in India is that held at Hurdwar in Hindustan. The town, although inconsiderable, is famous for being one of the principal places of Hindu pilgrimage, which takes place along with the fair at the vernal equinox.

The fairs of Portobello, Vera Cruz, and Acapulco, once so famous, are now totally deserted; and that of the Havannah is also much fallen off.

Fair, in nautical language, is used for the disposition of the wind, when it is favourable to a ship's course, in opposition to that which is contrary or foul. The term *fair* is more comprehensive than the term *large*, and includes about sixteen or eighteen points of the compass. *Large* is confined to the beam or quarter, that is, to a wind which crosses the keel at right angles, or obliquely from the stern, but never to one right a-stern.

FAIR ISLE, an island belonging to Zetland, lying between that group of islands and the Orkneys, extending fully three miles in length by about two in breadth, and of an oblong form. It is quite mountainous, with a precipitous and dangerous coast, which is only accessible upon the south-eastern side. It is inhabited; but the soil chiefly affords pasturage for sheep.

FAIRFAX, EDWARD, a poet of considerable note, who flourished in the reigns of Queen Elizabeth and James I. He was the second son of Sir Thomas Fairfax of Denton, in the county of York. The precise date of his birth is uncertain; and it has even been supposed that he was illegitimate; but there does not seem to be any good ground for such a supposition. The family of which he was descended had a strong propensity for the military profession; and his father having passed his youth in the wars of the Continent, was present at the sacking of Rome under Charles Duke of Bourbon, in the year 1527. In 1591 the poet's elder brother, Thomas, who afterwards became the first Lord Fairfax, received the honour of knighthood, before Rouen, on account of the bravery he had displayed whilst serving with the army sent to the assistance of Henry IV.; and the same individual afterwards signalized himself on many occasions in Germany. A younger brother, Charles, also distinguished himself in arms, having been present at the battle of Newport in 1600, and commanded at the famous siege of Ostend, where he received a wound in the face from a splinter of the skull of a marshal of France, who was killed near him by a cannon ball. But whilst his brothers were thus employed in military service abroad, Edward Fairfax devoted himself to the peaceful pursuits of literature at home, and the acquirements he made were such as would have qualified him to fill with credit any employment either in church or state. But an invincible modesty, joined to a love of retirement and a contemplative turn of mind, induced him to prefer the groves and cascades of Denton, and the forest of Knaresborough, to all the advantages of worldly distinction; and, accordingly, having fixed himself as a private gentleman at Fuyistone, he devoted his leisure to composition both in prose and in verse, and to the education of his own and the children of his brother, Lord Fairfax, who are said to have profited much by his instructions. In his book on Dæmonology, Fairfax has given the following character of himself:—"I am in religion," says he, "neither a fantastic puritan nor a superstitious papist, but so settled in conscience, that I have the sure ground of God's word to warrant all I believe, and the commendable ordinances of our English church to approve all I practise; in which course I live a faithful Christian and an obedient subject, and so teach my family." In these principles he persevered until his death, which took place about 1632, at Newhall, in the parish of Fuyistone, between Denton and Knaresborough. Fairfax's first, and indeed his principal work, was his translation of Tasso, which he executed when very young, and dedicated to Queen Elizabeth. The merits of this performance were at one time much overrated; and, latterly, it has been in some measure superseded by the translation of Hoole, which, though not a little stiff and formal, possesses greater equality, and is perhaps also superior in point of accuracy: but it must at the same time be confessed, that the diction of Fairfax is remarkable for its purity, freedom, and elegance; that his numbers are often highly musical; and that he is one of the few writers, if not the only one, down to the time of Sir William Davenant, who does not require an apology to be made for him on account of the age in which he lived. "Fairfax," says Hume, "has translated Tasso with an elegance and ease, and at the same time with an exactness, which for that age are surprising." But the poetical exertions of Fairfax did not terminate with this translation. He also composed eclogues, twelve in number, relative to the manners, the characters, and the incidents of the times; compositions which he seasoned with many fine touches of piquant satire, and dignified with useful lessons both in public and private morality. The fourth in order of these eclogues was printed in the *Muses' Library* in 1737; but it is somewhat surprising that the whole of them should never have been published, and it is not improbable that the manuscripts are now lost. Of the prose writings of Fairfax, most of which related to the controversy with the church of Rome, none has ever appeared in print; and even his treatise on Dæmonology, if yet extant, still remains in manuscript. This last production, which is entitled "A Discourse on Witchcraft, as it was acted in the family of Mr Edward Fairfax of Fuyistone, in the county of York, in 1621," and of which a copy was in the possession of Mr Isaac Reed, would no doubt, if published, throw considerable light on the superstitious opinions and feelings of the age when it was written, and might also perhaps contribute indirectly towards the true exposition of those spectral illusions and phantasms which, while they commanded the unhesitating belief, exercised so powerful an influence over the minds of our forefathers. Fairfax left several children, sons as well as daughters, the eldest of whom, William, a scholar of much the same temper with his father, though rather more cynical, translated Diogenes Laertius from Greek into English.

FAIRFAX, *Thomas Lord*, who acted so conspicuous a part during the civil wars in the reign of Charles I., and at length became general of the parliamentary forces, was the eldest son of Ferdinand Lord Fairfax, by Mary, daughter of Edmund Sheffield, Earl of Mulgrave, and was born at Denton in the parish of Otley, Yorkshire, in the month of January 1611. After the usual school education, he entered St John's College, Cambridge, where he studied some time, and imbibed that love of learning for which he was afterwards distinguished. Being of a martial disposition, he proceeded to Holland, where, in order to improve himself in the art of war, he served as a volunteer under Horatio Lord Vere. On his return to England he married a daughter of that officer, and retired to his paternal mansion at Denton, where he conceived an extreme aversion to the court, either by the instigation of his wife, who was a zealous Presbyterian, or by the persuasion and example of his father, who had become strongly disaffected towards the royal cause. Accordingly, when the king endeavoured to raise a guard for his own person at York, intending it, as the event afterwards proved, to form the nucleus of an army, he was employed by his party to present a petition to his sovereign, entreating him to hearken to the voice of his parliament, and to discontinue the raising of troops; and when Charles attempted to avoid receiving it, Fairfax followed him with the petition, which he presented upon the pommel of his saddle, in Heyworth-moor, before an assemblage of nearly a hundred thousand persons. Shortly afterwards, upon the breaking out of the civil war, his father having received from the parliament a commission appointing him general-in-chief of the forces in the north, Fairfax was at the same time made general of the horse under him. In this war both father and son distinguished themselves by their bravery, intelligence, and activity, particularly at the battle of Marston-Moor and the taking of York; Thomas Fairfax having been twice severely wounded, and having frequently exposed his life in the most daring manner. His exploits, therefore, gained him the confidence of his party; and, in 1645, when it was judged expedient to new-model the army, and to deprive Essex of the command, the parliament, knowing that Fairfax was a zealous Presbyterian, unanimously appointed him as successor to Essex. In this command Cromwell was joined with him in the capacity, and with the title, of lieutenant-general; but the latter only accepted the inferior grade in the hope, and most probably with the intention, of rendering himself really master.

As soon as Fairfax, who was then in the north of England, received the orders of parliament, he repaired to London, where he arrived on the 18th of February 1645, and was presented to the House of Commons on the following day, by four members, and complimented by the speaker, who handed him his commission. He had full powers to name all the generals under his orders; and, in the month of April, he proceeded to Windsor, where he employed himself in organizing the new army which the parliament had just voted. But it was in reality Cromwell who, under the name of Fairfax, constantly acted; for the lieutenant-general had acquired so great an ascendency over his chief, that he did, or caused to be done, whatever he pleased; and having had the address to persuade Fairfax that he had only in view the good of religion and the commonwealth, he thereby disposed the latter to receive his counsels, and to place entire confidence in his character. Being appointed governor of Hull, and sent by parliament to succour Taunton in Somersetshire, then closely besieged by the royalists, Fairfax, at the latter place, to which he had proceeded with all possible diligence, received counter-orders to join Cromwell with the forces under his command, and to watch the motions of the king, who had just quitted Oxford. After various movements, the hostile armies met, on the 14th of June, at Naseby in Northamptonshire, and a battle took place, which ended in the total discomfiture of the royalists. The king was obliged to fly from the field, and retired into the country of Wales. On the 16th the victorious Fairfax laid siege to Leicester, which surrendered two days afterwards. On the 10th July he offered battle to Lord Goring, who had been obliged to raise the siege of Taunton; on the 22d he carried Bridgewater by assault, and thereafter took several other places; and on the 10th September he forced Bristol to capitulate. Having reduced to subjection the whole country to the west of London, he next marched to the south; but finding it impossible, from the rigour of the season, to besiege Exeter, a well fortified city, in regular form, he converted the investment into a blockade, which lasted until the 13th of April 1646. In this interval he took several places, defeated and dispersed different bodies of royalists, and completely humbled, or rather annihilated this party in the provinces of the south and west, which had formed its great stronghold and constituted its principal resource in England. Having obtained these successes, Fairfax marched in all haste to Oxford, where was the most considerable garrison that yet remained to the king. But the latter, afraid of being shut up in the place, and thus falling into the hands of his mortal enemies, withdrew secretly, in disguise, and proceeded to Newark, to throw himself into the arms of the Scotch. Oxford capitulated, and by the end of September Charles had neither army nor garrison in England.

Fairfax having arrived in London on the 12th November, was complimented and thanked for his successes by the two houses of parliament, who repaired to his residence for the purpose. But he had scarcely time to enjoy a little repose from the fatigues of war, when he received a commission to escort the two hundred thousand pounds, granted by the English parliament to the Scotch army, in name of arrears of pay, but, in reality, according to some, as the price of the king's person, which that army had consented to give up. Charles was delivered up to the commissioners of parliament on the 30th January 1646. Fairfax, who preceded the king, having met him beyond Nottingham, dismounted from his horse, kissed the royal hand, and having resumed his seat, discoursed with the unfortunate prince during the journey to Holdenby. That Charles was satisfied with the conduct of Fairfax, appears from the observation which he addressed to one of the parliamentary commissioners. "The general," said he, "is a man of honour, and keeps his word which he had pledged to me;" a remark, the precise import of which, however, is not understood, as the circumstances to which the king evidently alludes have not been stated by any historian. Fairfax was received at Cambridge with the greatest honours, and created master of arts. By this time the parliament, after long debates, had appointed him general of the forces, which were still to be kept on an effective footing; for it was now intended to disband the greater part, and send the remainder to Ireland. But the soldiers being extremely dissatisfied with a project which threatened to deprive them of all the advantages they had reaped from the war, Cromwell, who had hitherto allowed Fairfax to enjoy in appearance the honours of supreme command, resolved, in concert with Ireton, his son-in-law, a man not less crafty than himself, but a better speaker and a more able writer, to profit by this disposition of the army, in order to foment a revolt against the parliament. Accordingly, they circulated a report among the soldiers, that the parliament, having the king in its power, intended to disband the greater part of the army, in order to deprive them of their arrears of pay, and to send the rest into Ireland, to be exterminated by the fierce inhabitants of that island. Inflamed by these rumours, the army, on the suggestion of Ireton, appointed a committee of its own number, to consult for its wellbeing, assist at the councils of war, and watch over the peace and security of the kingdom. Fairfax now observed with regret, that these agitators, as they called themselves, had usurped the power which he should have exercised over the army; he discerned that they were the forerunners of anarchy, and that their design was to raise their own fortune on the ruin of the state. He therefore resolved to resign his commission; but the chiefs of the Independents, whose projects were not fully matured, persuaded him to retain it. He then, with culpable weakness, co-operated in all the proceedings of the army, which had for their object to destroy the power of parliament. In vain did the two houses enjoin him to leave his troops at the distance of at least fifteen miles from London; he entered that city in triumph, with the speaker and sixty members of the House of Commons, who, betraying the privileges of parliament, had retired to the camp, and whom he now re-instated in their places. For this proceeding, which in any view deserved a halter, he was rewarded with the thanks of both houses, and the office of governor of the Tower. But having soon afterwards learned that the king had been removed by violence from Holdenby, Fairfax, indignant at this proceeding, repaired to the place where this unfortunate prince was detained near Cambridge, conducted himself towards the royal captive in the most respectful manner, and caused him to follow all the movements of the army, in order that the parliament might not obtain possession of his person, for which purpose commissioners had already been named by both houses. The credit of Fairfax with the troops, however, diminished daily; he had neither firmness of will nor force of character sufficient to oppose himself to a power which had long overtopped his own; and although he had in view none of the objects which Cromwell cherished, he contributed to render them all successful. It was doubtless in consequence of this inconceivable weakness that he concurred in the manifesto of the army, published in the month of January 1648, which adhered to the vote of the commons, that no more addresses or messages should be presented to the king, and protested that it would obey parliament in every thing which might henceforth be necessary for the government of the kingdom and the safety of parliament, whether with the king or against him.

At this period Fairfax lost his father, whom he succeeded in his titles and employments; but still he remained, as before, the docile instrument of the ambition of Cromwell. He displayed the greatest activity in putting down insurrections, and took Colchester, whither the remains of the royalist party had betaken themselves. At the end of the year he returned to London, in order to keep in check that city and the parliament; and he took up his head-quarters in the palace of Whitehall. Here, being struck with a sort of moral stupefaction, which prevented him from reflecting on the character or tendency of his own actions, all his proceedings served to accelerate the crisis of the king's fate; but although placed at the head of the judges before whom Charles was to be tried, he refused to act, probably at the instigation of his wife, who on this occasion displayed a boldness and intrepidity worthy of all admiration. He even exerted himself to prevent the execution of the sentence, and tried to persuade his regiment to rescue the king from the hands of those who had condemned him to death. But Cromwell and Ireton, ably assisted by Harrison, imposed on the pious credulity of Fairfax; and, whilst these hypocrites kept the imprudent general engaged in prayer, the fatal blow was struck. A few days after the execution of Charles, he was appointed a member of the council, but refused to sign the form of oath by which all that had been done relative to the king and to the royal authority was approved of. Towards the end of March he received the title of general of the troops in England and in Ireland; but he no longer possessed any real power. He marched against the levellers, who having become numerous, had occasioned considerable uneasiness, and would soon have rendered themselves formidable, and completely routed them at Burford in Oxfordshire. He then repaired to Oxford, where he received the degree of doctor of laws; after which he proceeded to allay the troubles in Hampshire, assembled the army at Guildford, exhorted it to obedience, and returned to London, where he was presented with a basin and ewer of beaten gold. In June 1650, when the Scotch had declared for Charles II., the council of state in England having resolved to send an army to Scotland, in order to prevent an invasion, Fairfax was consulted respecting the design, which he appeared at first to approve; but afterwards, by the persuasion of his lady and the presbyterian ministers, he declared himself satisfied that the parliament of England had no just ground for sending an army to invade Scotland; and, in terms of this declaration, he resigned his commission. The supreme command of the army was then conferred upon Cromwell, who saw with pleasure the retirement of a man who, being no longer necessary to his ambitious projects, now formed an obstacle to their entire accomplishment. The parliament, however, in some measure indemnified Fairfax, by granting him a pension of five thousand pounds sterling.

Being thus released from all public employment, Fairfax retired to Nunappleton, Yorkshire, where he passed his time in tranquillity, earnestly praying, it is said, for the restoration of the royal family, and resolved to seize the first opportunity which offered to contribute towards its accomplishment. Accordingly, when General Monk invited him to assist in the operations about to be undertaken against Lambert's army, he promptly obeyed the call, and on the 3d December 1659 appeared at the head of a body of Yorkshire gentlemen; and such was the influence of his name and reputation, that the Irish brigade, consisting of twelve hundred horse, quitted Lambert's colours and joined him; an event which was speedily followed by the breaking up of all Lambert's forces. On the 1st January 1660 he made himself master of York, and on the 2d he was chosen by the Rump Parliament, one of the council of state, an appointment which was renewed on the 23d of February ensuing. On the 29th of March he was elected one of the knights of the county of York in the healing parliament; and he was put at the head of the commission appointed by the House of Commons, on the 3d of May, to wait upon Charles II. at the Hague, and urge his speedy return. After the dissolution of the healing parliament, which was of short duration, he again retired to his seat in the country, where he lived, in a manner strictly private, till his death, which happened on the 12th of November 1671, in the sixtieth year of his age. In person Lord Fairfax was tall, but of a gloomy and melancholy disposition. He was, however, of a meek and humble demeanour, and of few words in discourse or council; but when his judgment had once been satisfied, he remained unalterable, and frequently acted in opposition to the opinions of his council. His valour was unquestionable, though not of a cool and steady, but rather of a passionate and excited kind; in battle he seemed transported beyond himself, and appeared like one distracted and furious. In a word, Fairfax would have been considered as the greatest of the parliamentary commanders, had not his exploits been eclipsed by the more brilliant achievements of Cromwell; and he would have been thought one of the greatest heroes of the rebellion, if the extreme narrowness of his genius in every thing but war had not disqualified him for shining as a statesman.

Lord Fairfax had some taste for literature, and both at York and at Oxford endeavoured to save the libraries from pillage. He also presented twenty-nine ancient manuscripts to the Bodleian library, including a beautiful one of Gower's *Confessio Amantis.* Lord Orford has introduced him not only as an historian, but as a poet, among his royal and noble authors; and in Thoresby's Museum the following pieces were preserved in manuscript, viz. 1. the Psalms of David; 2. the Song of Solomon; 3. the Canticles; 4. Songs of Moses, and other parts of Scripture, versified; 5. a Poem on Solitude; 6. Notes of Sermons; and 7. a Treatise on the Shortness of Life. But of all his productions, the most curious was a copy of verses written on the horse which Charles II. rode at his coronation, and which had been bred and presented to the king by his lordship; a strange tribute, no doubt, from the veteran hero of republicanism and the covenant. Besides these, several of his manuscripts are preserved in the library at Denton, of which a list has been published in Park's edition of Lord Orford's *Royal and Noble Authors.*

FAIRFORD, a market-town of Gloucestershire, in the hundred of Brightwalls Barrow, 80 miles from London. It is situated on the small river Coln, at its junction with the Thames, over which are two bridges. The church is a remarkably fine Gothic structure, erected about the year 1470 by an individual; and the painted window, said to have been captured by a ship belonging to the founder, a merchant of London, is highly beautiful. It is about three miles from the Thames and Severn Canal, by which some trade is carried on in coals, salt, and other heavy goods. The market is held on Thursday. The population amounted in 1801 to 1326, in 1811 to 1444, in 1821 to 1547, and in 1831 to 1574.

FAIRY, in ancient traditions and romances, signifies a sort of sprite, or imaginary genius, of this lower sphere, and distinguished by a variety of fantastical actions either good or bad.

Fairies were commonly imagined to be women of an order superior to human nature, yet subject to wants, passions, accidents, and even death; sprightly and benevolent whilst young and handsome; morose, peevish, and malignant, if ugly, or in the decline of their beauty; and fond of appearing in white, from which circumstance they were often called the White Ladies.

Concerning these imaginary beings, Jervaise of Tilleberry, marshal of the kingdom of Arles, who lived in the beginning of the thirteenth century, writes thus in a work inscribed to the Emperor Otho IV.:—"It has been asserted by persons of unexceptionable credit, that fairies used to choose themselves gallants from among men, and rewarded their attachment with an affluence of worldly goods; but if they married, or boasted of a fairy's favours, they as severely smarted for such indiscretion." Similar tales still were current in Languedoc; and throughout the whole province there was not a village without some ancient seat or cavern which had the honour of being a fairy's residence, or at least some spring in which a fairy used to lave its tiny form. This idea of fairies has a near affinity with that of the Greeks and Romans concerning the nymphs of the woods, mountains, and springs; and an ancient scholiast on Theocritus says, that "the nymphs are demons which appear on the mountains in the figure of women." The Arabs and other orientals have also their *Peris*, of whom they entertain notions somewhat similar to those held in the west respecting fairies.

But fairies have likewise been described as of either sex, and generally as of small stature, though capable of assuming various forms and dimensions. The most charming representation of these children of romantic fancy is to be found in the *Midsummer Night's Dream*, in referring to which we no doubt have been already anticipated by the recollection of the reader.

Fairy of the Mine, an imaginary being, an inhabitant of mines. The Germans believed in two species: one fierce and malevolent; the other a gentle race, appearing as little old men dressed like the miners, and not much above two feet in height. These sprites wander about the drifts and chambers of the works; seem perpetually employed, yet do nothing; and appear to cut the ore, or fling what is cut into vessels, or turn the windlass; but never do any harm to the miners, unless provoked. Such is the relation of Agricola, in his book *De Animantibus Subterraneis.*

Fairy Circle, or *Ring*, a phenomenon pretty frequent in the fields, and supposed by the vulgar to have been traced by the fairies in their dances. There are two kinds of fairy ring: one of about seven yards in diameter, containing a round bare path, about a foot broad, with green grass in the middle of it; and another of different dimensions, encompassed with a circumference of grass. Jessop and Walker, in the *Philosophical Transactions*, ascribe these rings to lightning; and this is thought to be confirmed by their being most frequently produced after thunder storms, as well as by the colour and brittleness of the grass-roots when first observed. Lightning, like all other fires, moves round, and burns more in the extremity than in the middle; and the second circle arises from the first, as the grass burnt up grows very plentifully afterwards. But others maintain that these circles are formed by ants, which are frequently found in great numbers therein. Mr Cavallo, in his *Treatise on Electricity*, does not think that lightning is at all concerned in the formation of them. "They are not," says he, "always of a circular figure; and, as I am informed, they seem to be rather beds of mushrooms than the effects of lightning."

FAITH, in *Theology*, that assent which we give to a proposition advanced by another, the truth of which we do not immediately perceive from our own reason or experience; or it is a judgment or assent of the mind, the motive of which is not so much any intrinsic evidence, as the authority or testimony of some other who reveals or relates it. Hence, as there are two kinds of authorities and testimonies, the one of God and the other of man, faith becomes distinguished into divine and human. *Divine faith* is that founded on the authority of God; or it is that assent which we give to what is revealed by God. The objects of this faith, therefore, are matters of revelation. *Human faith* is that by which we believe what is told us by men; and its object is matter of human testimony and evidence.

FAITH, in practical theology, constitutes the first of the theological virtues or graces.

Faith in God, in this sense, denotes such a conviction of his being, perfections, character, and government, as produces love, trust, worship, obedience, and resignation. Faith in Christ, as it has been defined by some theologians, is a mere assent to the gospel as true; but according to others, it signifies such a persuasion that he is the Messiah, and such a desire and expectation of the blessings which he has promised in his gospel to his sincere disciples, as engage the mind to fix its dependence upon him, and to subject itself to him in holy obedience. Faith likewise, in respect of futurity, is a moral principle, implying such a conviction of the reality and importance of a future state, as is sufficient to regulate the etmper and conduct in the affairs of this life.

FAITHORN, WILLIAM, an ingenious English artist, a native of London, was the disciple of Peak the painter, with whom he worked three or four years. At the breaking out of the civil war, Peak espoused the cause of his sovereign; and Faithorn, who accompanied his master, was taken prisoner by the rebels at Baringhouse, whence he was sent to London, and confined in Aldersgate. In this uncomfortable situation he exercised his graver; and a small head of the first Villiers, Duke of Buckingham, in the style of Melan, is reckoned as one of his performances at this period. The solicitations of his friends in his favour at last prevailed; and he was released from prison, with permission to retire to the Continent. In France he found encouragement and protection from the Abbé de Marolles; and it was at this time that he formed an acquaintance with Nanteuil, from whose instructions he derived very considerable advantage. About the year 1650 he returned to England, and soon afterwards married the sister of a Captain Cround, by whom he had two sons, Henry, who became a bookseller, and William, an engraver in mezzotinto. Faithorn opened a shop near Temple-Bar, where he sold not only his own engravings, but those of other English artists, and imported a considerable number of prints from Holland, France, and Italy. About the year 1680 he retired from his shop, and resided in Printing-House Yard; but he still continued to work for the booksellers, especially Royston, Martin, and Peak the younger, his former master's brother. He painted portraits from the life in crayons, an art which he had learned of Nanteuil during his abode in France; he also painted in miniature; and his performances in both these styles were much esteemed. But his spirits were broken by the indiscretion and dissipation of his son William; and a lingering consumption put an end to his life in 1691. He wrote a book *Upon Drawing, Graving, and Etching,* for which he was highly commended by his friend Thomas Flatman the poet.

FAKENHAM, a market-town of Norfolk, in the hundred of Gallon, 109 miles from London. It is situated in an open district, but fertile, especially in wheat and barley, with a large corn market on Thursday, but little other trade, since the spinning of worsted has been performed by machinery. The river Var runs near it towards Lynn. The church is a very handsome building. The population amounted in 1801 to 1236, in 1811 to 1382, in 1821 to 1626, and in 1831 to 2077.

FAKIRS, or FAKEERS, Indian monks or friars, some of whom exceed in severities and mortifications the ancient anchorites or solitaries, though the greater part are rogues, who assume this character in order to pass an idle and vagabond life.

FALAISE, an arrondissement of the department of Calvados, in France, extending over 336 square miles. It is divided into five cantons, and these again into 142 communes, containing 71,500 inhabitants. The capital is the city of the same name, situated on the river Ante. It is well built, and contains 13,960 inhabitants, who are occupied in making serges, linen, thread-lace, cotton goods, leather, and cutlery, and in distilling brandy. This place gave birth, in the year 1027, to William the Conqueror, in the castle, the ruins of which are among the finest remains of antiquity in France. Long. 0. 10. W. Lat. 48. 45. N.

FALASHA, a people of Abyssinia, described by Bruce, and supposed to be of Hebrew origin. According to the received accounts, the Falasha are the descendants of those Jews who went from Palestine into Ethiopia, as attendants of Menilek, the son of the queen of Sheba or Saba by Solomon. But the language of this people is very different from the Hebrew, Samaritan, or any other which the Jews ever spoke in their own country. On being interrogated concerning it by Bruce, they said that it was probably one of the dialects spoken by the nations on the Red Sea, among whom they had settled at the period of their first emigration.

FALCADE, in the manège, the motion of a horse when he throws himself upon his haunches two or three times, as in very quick curvets, which is done in forming a stop and half stop.

FALCATED, something in the form of a sickle. Thus, the moon is said to be *falcated* when she appears horned.

FALCO, the eagle and hawk. See ORNITHOLOGY.

FALCON, a name bestowed on various birds of prey, but chiefly on such as are serviceable to man for the pursuit of game. See ORNITHOLOGY *Index*.

FALCONER, WILLIAM, a poet of considerable eminence, born at Edinburgh about the year 1730, was the son of a poor but industrious barber, all of whose children, except the subject of the present notice, were either deaf or dumb. William appears to have passed but a short period at school, where he received the scanty education required to qualify him for an inferior employment; yet he is believed to have contracted a taste for reading, and a desire for higher attainments than his circumstances permitted him to aspire to. At an early age he was entered as an apprentice on board a merchant-vessel belonging to Leith; and Dr Currie mentions, on the authority of a naval surgeon, that he afterwards served as a common sailor on board the ship of which Campbell, author of *Lexiphanes,* was purser, and attracted the notice of that individual by indications of talent which were deemed by him worthy of cultivation. How long he continued in this humble capacity is not known; but by some friendly intervention, he was appointed second mate of a vessel called the Britannia, employed in the Levant trade, which, however, was wrecked during her passage from Alexandria to Venice, and only three of the crew, including Falconer, saved. This event, the date of which has not been ascertained, appears to have made a deep impression on his mind, and probably suggested the idea of his poem entitled *The Shipwreck,* on which his reputation chiefly rests. The first essays of his muse attracted little attention, and were probably commonplace enough; though, if Clarke be right in the opinion that he was the author of "Cease, rude Boreas," an exception must, of course, be made in favour of that popular song. Falconer is supposed to have continued in the merchant service until the spring of 1762, when he recommended himself to the notice of Edward Duke of York, by the dedication of *The Shipwreck,* and enlisted his royal highness amongst the number of his admirers and patrons. Desirous to place him in a situation where he could be befriended, the duke advised him to enter the navy; and before the end of summer, he was rated as midshipman on board the Royal George. But as this ship was paid off at the peace of 1763, and as Falconer's period of service had been far too short to enable him to obtain the commission of lieutenant, he was advised to exchange the military for the civil department of the navy; and, in the course of the same year, he received an appointment as purser of the Glory frigate, a situation which he held until that vessel was laid up in ordinary at Chatham. Being thus once more left without professional employment, he devoted his leisure to literary pursuits. In 1764, he published a new edition of *The Shipwreck*, in 8vo, corrected and enlarged; and the following year appeared *The Demagogue*, a political satire, intended as a sort of antidote to the writings of Wilkes and Churchill, but much more remarkable for virulence than wit. His time, however, was chiefly occupied with the compilation of an *Universal Marine Dictionary*, a work much wanted, and which, when brought out in 1769, was received with general approbation. Before this period he appears to have left his retreat at Chatham for an abode of a less comfortable kind in the metropolis, where, depressed by poverty, that evil-spirit which tracks the footsteps of genius, he subsisted for a time on various resources. But, in the midst of his difficulties, when his situation had become truly distressing, he received an appointment to the pursership of the Aurora frigate, which had been commissioned to carry out to India Messieurs Vansittart, Scrofton, and Forde, as supervisors of the Company's affairs; and he was also promised the office of private secretary to these functionaries. From this favourable turn of fortune the friends of the poet, whilst they rejoiced in the present relief which it afforded, conceived him in a fair way eventually to realize a competent independence; but *dis aliter visum*, Providence had decreed it otherwise. The Aurora sailed from England on the 30th September 1769, and after touching at the Cape of Good Hope, was never more heard of; she was supposed to have foundered in the Mozambique Channel, but not a trace remained by which the cause of the calamity could be discovered, or even conjectured.

Besides the productions already mentioned, Falconer was the author of several pieces, the most considerable of which are an Ode on the Duke of York's second departure from England as rear-admiral, and a Poem on the death of Frederick, Prince of Wales. But as these and similar effusions could never have survived the occasion which produced them, his fame as a poet must entirely rest on *The Shipwreck*, which, with all its faults, has a fair chance of immortality, appealing, as it does, directly to the feelings of one class of men, and indirectly to the natural sympathies of all. There is a warmth in its colouring, and a reality in its descriptions, which strongly impress the minds particularly of youth, and, notwithstanding the didactic character of the poem, sustain its interest, and enliven even the duller parts by a sort of reflected radiance. Natural feeling, natural imagery, and natural truth, are expressed in natural language, which, if it never rises to a great elevation, seldom sinks below the dignity of the subject, and is throughout animated by a glow of feeling which awakens a kindred emotion in the breast of the reader. Falconer has no striking outbursts of genius; he does not aspire to produce a great effect by a few bold touches, or the rapid and masterly grouping of appalling or horrible circumstances. He labours in detail, bringing before us, without apparent effort, the events as they arise, and conducting us with an interest constantly increasing towards the catastrophe. He paints with minute fidelity as well as picturesque effect; but it is from the general result, rather than from any portion or portions of the work considered separately, that the talents of the artist should be judged. Such a tremendous picture of shipwreck as that which Byron has, in wild sportiveness, thrown out in Don Juan, immeasurably transcends the powers of Falconer, and indeed stands alone in its terrible sublimity; but, on the other hand, the latter, by the careful elaboration of natural circumstances, and the general truth of his delineation, ultimately impresses the mind of the reader, if not with such vivid force, perhaps with even more enduring effect. Of the didactic merits of the poem, nautical men, who are necessarily the most competent judges in this particular, have spoken in terms of high commendation; and it has even been said that the rules and maxims therein delivered for the management of a ship in a perilous emergency are the very best which a practical mariner could adopt. But in our estimation this forms one of the principal defects of the poem considered as such, though it fell in with the spirit of the time when *The Shipwreck* was produced, and may still recommend it to sailors; nor by ordinary readers, who cannot understand or appreciate this sort of instruction, is it likely to be viewed in any other light than as an incumbrance to the march of the narrative and the progression of events.

FALCONRY, a field sport considered as of high importance in former ages, though greatly fallen into disuse in recent times. See FALCON in ORNITHOLOGY *Index*.

FALKIRK, a town of Scotland, in the county of Stirling. It is beautifully situated on the face of an eminence which overlooks the wide expanse of country called the Carse of Falkirk, and consists of one broad street, with a number of narrow streets and lanes branching off from it, or running parallel to it. The houses are in general lofty and well built; and the High Street is ornamented by a spire and clock of modern erection. Besides the parish church, there are a number of meeting-houses for dissenters. Several fine villas have recently been built towards the north of the town, and form a handsome continuation of it, uniting it with the villages of Grahamstone and Bainsford. Falkirk enjoys considerable trade; but the only manufacture carried on is one of leather. The inland trade constitutes the support of the town, the populous neighbourhood being supplied by it with most of the necessaries of life. The Carron iron-works, which are very extensive, are situated about two miles north of the town, and the numerous individuals there employed make Falkirk their general market. There are also some extensive coal-works, distilleries, malt-works, and flour-mills, in the immediate neighbourhood; and brewing is carried on to some extent. Falkirk is thus calculated to be a commercial depôt for a population amounting to nearly thirty thousand individuals. The town is chiefly noted for its three great cattle markets or *trysts*, held annually in August and the two following months. These markets are considered as amongst the largest in Great Britain, and to them a vast quantity of live stock of every description is brought. The traffic carried on in Falkirk is assisted by branches of the Bank of Scotland and Commercial Banking Company. It was at one time a burgh of barony under the earls of Linlithgow; but since the fall of that family, and the abolition of the heritable jurisdictions, it has possessed no form of municipal government. The affairs of the town are administered by a body of stent-masters, chosen by the different trades. A justice-of-peace court is held on the first Monday of every month. Falkirk is a town of considerable antiquity, and appears to have been a place of some note in the early part of the eleventh century. Its original name was Eglisbreck, which signifies the "speckled church," in allusion, it is supposed, to the colour of the stones, and translated by Buchanan *varium sacellum*. The old church, which was demolished in 1810, was erected in 1057, the year in which Malcolm Ceanmore assumed the sovereignty. The new church, which was built upon the site of the old one, in front of the town, is a very plain edifice, with an ancient spire attached to it. In the neighbourhood of this town was fought a celebrated battle between the Scotch and English, during the period when Edward I. of England attempted to usurp the sovereignty of Scotland. The Scotch, under Cuming of Badenoch and the renowned Sir William Wallace, were worsted, and two Scottish chiefs, Sir John Graham and Sir John Stewart, fell in the conflict. Their graves are still pointed out in the churchyard; and over the former a monument was erected with an inscription, which has been from time to time renewed. A second battle was fought here on the 17th of January 1746, between the royalists and the insurgents under Prince Charles Edward Stuart. The population of Falkirk, in 1821, amounted to 4000, and in 1831, including the parish, to 12,743. It is at the distance of twenty-four miles from Edinburgh, and twenty-two from Glasgow.

FALKLAND, a small town of Scotland, in the county of Fife, and the chief place of a parish of the same name. It is situated in rather a secluded part of the district, some miles west from the great thoroughfare through the county. It consists of a single street, broad and spacious at the east end, but insignificant at the opposite extremity, with several cross lanes. The houses are in many cases covered with thatch, and of an antique and primitive appearance. The chief occupation here is weaving; but there is little or no traffic of any kind. The principal attraction in Falkland is the royal palace, originally a stronghold belonging to the Macduffs, earls of Fife. On the attainder of Munro Stewart, the seventeenth earl, it became forfeited to the crown in 1424. James V. who was very fond of the place, enlarged and improved it. The remains evince its former magnificence and elegance, and the fine taste of the princely architect. The gateway is placed between two fine round towers, and on the right hand adjoins the chapel, whose roof is of wood, handsomely gilt and painted, but in a most ruinous condition. Beneath are several apartments. The front next to the court was beautifully adorned with statues, heads in bas-relief, and elegant columns not reducible to any order, but of fine proportion, with capitals approaching the Ionic scroll. Beneath some of these pillars was inscribed I. R. M. G. 1537, or *Jacobus Rex, Maria de Guise.* This place was also a favourite residence of James VI. on account of the fine park and abundance of deer. The east side was accidentally burnt in the time of Charles II. and the park ruined during Cromwell's usurpation, when the fine oaks were cut down in order to build a fort at Perth. There are various historical associations connected with Falkland. In a dungeon of the original castle, which is supposed to have constituted the north side of the court-yard of the palace, Robert, Duke of Rothesay, brother of James I. was ~~starved~~ to death by his uncle Albany. Falkland was erected into a burgh by James II. in 1458; and in 1595 James VI. renewed and confirmed its charter. The population of the place amounted in 1821 to 1050, and in 1831 to 2658.

Falkland, *Lord.* See Carey.

FALL, the descent of a heavy body towards the centre of the earth. It is also the name of a measure of length used in Scotland, containing six ells.

Fall of Man, in sacred history, that memorable event by which sin and death were introduced into the world. The account which Moses has given of this transaction is extremely concise; and hence several learned men, finding a difficulty in interpreting his statement, have been inclined to believe that all which is contained in Scripture on the subject ought to be taken in an allegorical sense, and not according to the strictness of the letter. They allege that the ancients, particularly the eastern nations, had two different ways of delivering their divinity and philosophy, one popular, and the other mysterious; that the Scripture uses both occasionally, sometimes accommodating itself to the capacities of the people, and at other times to the real but more veiled truth; and that, to obviate the many difficulties which occur in the literal history of this sad catastrophe, the safest way is to understand it as a parabolical story, under which the real circumstances are disguised and concealed, as a mystery not fit to be more explicitly declared.

FALLING Sickness, or Epilepsy. See Medicine.

Falling-Stars. See Star.

FALLOPIAN Tubes, in *Anatomy*, two ducts arising from the womb, one on each side of the fundus, and thence extending to the ovaria, and which have a considerable share in conception. They are called *tubæ*, from their form, which bears some resemblance to a trumpet; and their denomination of Fallopian they derive from Gabriel Fallopius, by whom they were first discovered.

FALLOPIUS, or Falloppio, Gabriel, a celebrated anatomist and surgeon of the sixteenth century, was born at Modena in 1523. Although he taught anatomy with great distinction, and enjoyed an immense reputation, the details of his life are not exactly known, and have been variously related by different biographers; some, as Tommasini and Ghilini, fixing his birth in 1490, which is a manifest error, refuted by Fallopius himself; and others, again, contending that he was the disciple of Vesale, although Martine and Haller attest the contrary. But be this as it may, Fallopius made great progress in medical study, first at Ferrara under Antonio Musa Brassavola, and afterwards at Padua. For a time, indeed, he possessed a canonry in the cathedral of Modena; but he soon renounced this function, which prevented him from indulging his taste for dissection. After having taught anatomy for some months in the university of Ferrara, and during three years in that of Pisa, he was chosen by the senate of Venice, in 1551, to fill the chair of anatomy and surgery at Padua. He was, besides, entrusted with the demonstration of medicinal plants, and the inspection of the botanic garden, which he enriched with several vegetables collected during his travels in Italy, France, and Greece. But whilst discharging with equal zeal and distinction the various duties which these functions imposed upon him, his career was suddenly arrested by death, on the 9th of October 1562, before he had attained the fortieth year of his age. Fallopius only published a single work, which is not voluminous, but full of curious facts and useful discoveries; it is entitled *Observationes Anatomicæ*, Venice, 1561, in 8vo, also, Padua, 1562, Paris, 1562, Cologne, 1562, Helmstadt, 1588; and certainly forms an epoch in the annals of anatomical science. It is the first work, indeed, in which we find the exact osteology and augiology of the fœtus; notions perfectly sound in regard to the epiphyses; and a luminous description of the delicate and complicated organ of hearing. The illustrious author clearly makes known the cochlea, the demi-circular canals, and the tortuous canal, which still bears the name of Fallopius. He describes, with a care formerly unknown, the ethmoid and sphenoid bones, the alveolar processes in which the teeth are encased, and the arteries, with the veins and nerves connected with them. He has likewise bequeathed his name to the ligament which runs from the anterior point of the ileon to the symphysis pubis. He points out, sometimes individually, at other times with more of method and detail, the occipital, palatine, laryngian, pharyngian, and pyramidal muscles of the abdomen; also the auricular, ocular, and facial muscles; together with the elevator of the eyebrow, and the sphincter of the bladder. Less profound in the knowledge of the vessels, he nevertheless enriched that portion of anthropotomy. Before his time anatomists had the most confused and inaccurate ideas respecting the sinus of the spinal marrow, the carotid, meningean, and ethmoidal arteries, the jugular and vertebral veins, and the origin of the artery of the penis. Nor was neurology less indebted to the researches of Fallopius, who discovered the fourth pair of nerves, enumerated the three branches of the fifth, and completed the description of the eighth. Lastly, he carried the same critical spirit into splanchnology in general, over which he diffused much light, particularly in regard to the different sets of apparatus for secreting the bile, the urine, and the semen ; and he also traced an excellent description of the clitoris, of the round ligaments, and of the extremities of the womb. To this enumeration of the anatomical labours of Fallopius it may be added, that he was powerfully seconded in his efforts by the principal men of the state. The protection afforded him by the grand duke of Tuscany was carried a length which may probably strike our readers with horror : *Princeps jubet ut nobis dent hominem, quem nostro modo interficimus, et illum anatomisamus.* The unfortunate men here alluded to were no doubt criminals ; yet it is impossible to avoid being shocked beyond expression by the perusal of these words. The lectures of Fallopius were published, after his death, by several of his disciples ; but none of the latter seems to have performed this task in a manner either creditable to himself or worthy of the great teacher of anatomy by whom they were delivered.

FALMOUTH, a sea-port of the county of Cornwall, in the hundred of Kerriar, 273 miles from London, at the spot where the river Fale falls into the sea. It has risen to importance from the excellence of its harbour, which is capable of containing large fleets of heavy ships in perfect security ; though difficult to get out of when the wind is easterly, and consequently fair for the passage across the Atlantic. The Lisbon packets sail regularly from this port, and at one period a beneficial trade was extensively carried on by them. Falmouth has now a considerable trade in the pilchard fishery. Near to it is Pendennis Castle, one of the defences of the harbour, built in the reign of Henry VIII., improved by Elizabeth, and greatly strengthened by Cromwell. It was occupied as a prison for Americans captured at the early stages of the war with the colonies in 1776. There are markets on Tuesday, Thursday, and Saturday. The population amounted in 1801 to 4849, in 1811 to 5307, in 1821 to 6374, and in 1831 to 7284.

FALSE, in general, something contrary to truth, right, or justice. Thus, we say a false action, false weights, false claim, and the like.

FALSI CRIMEN, in the civil law, is fraudulent subornation or concealment, with design to darken or hide the truth, and make things appear otherwise than they are. The *crimen falsi* is committed, first, by words, as when a witness swears falsely ; secondly, by writing, as when a man antedates a contract, or the like ; and thirdly, by deed, as when he sells by false weights and measures.

FALSIFY, in *Law*, is used for proving any thing to be false. Hence we find falsifying a record for showing it to be erroneous.

FALSTER, an island in the Baltic, forming a part of the kingdom of Denmark. It is separated from Zealand by the Gaade Sound, from Langeland by Guldborg Sound, and from Moen by Green Sound. In extent it is 184 square miles, and contains 16,500 inhabitants, in two cities and thirty parishes. Its produce of corn exceeds its consumption ; and it assists other parts of the kingdom with some supplies of butter, meal, live cattle, and fruit. The chief town is Mykopping, on Guldborg Sound.

FALU, one of the provinces of northern Sweden. It is bounded on the north by Hernosand, on the east by Gefleborg, on the south-east by Wastera, on the south by Orebro, on the south-west by Carlstadt, and on the west by Norway. It extends over 12,980 square miles, comprehends three cities, one market-town, and 1747 insulated establishments, and contains 124,816 inhabitants. The province is generally mountainous, the highest points rising to about 4000 feet above the level of the sea. Some agriculture is practised in the southern part, and rye, barley, and oats are grown ; but in the north nothing is to be seen except barren wastes. There are annually upwards of 2000 head of cattle brought from other parts to supply the few inhabitants who can afford to indulge in their flesh. The chief products are wood, potash, pitch, and tar from the soil, and iron, copper, and porphyry from the mines.

FALU, a town of Sweden, the capital of the province of that name. It is situated between the lakes Warpen and Runn, on a river which flows from one to the other. It is an ancient town, containing chiefly wooden houses to the number of 1135, and 4709 inhabitants, who chiefly find employment in the mines around them, but in some degree from various manufactures. Long. 15. 29. 34. E. Lat. 60. 35. 49. N.

FAMA CLAMOSA, in the judicial procedure of the church of Scotland, a ground of action before a presbytery against one of its members, independently of any regular complaint by a particular accuser.

Any person who is of good character may prefer to the presbytery a complaint against one of their members ; but the presbytery is bound not to proceed to the citation of the person accused, until the accuser under his hand shall give in the complaint, with some account of its probability, and undertake to make out the libel, under the pain of being considered as a slanderer. But when such an accusation is brought before them, they are obliged to examine or try the case. Besides this, however, the presbytery considers itself obliged to proceed against any of its members, if a *fama clamosa* of the scandal is such that the person implicated cannot be vindicated unless they begin the process. This they can do without any particular accuser, after they have inquired respecting the origin, occasion, and authors of this report. It is a maxim in the kirk of Scotland, that religion must suffer if the scandalous or immoral actions of a minister are not corrected ; and wherever a minister is reputed guilty of any immorality, although previously the most popular preacher in the kingdom, none almost will attend upon his ministry. Therefore the presbytery, for the sake of religion, is obliged to proceed against a minister in case of a *fama clamosa*. This, however, is generally done with great tenderness. After they have considered the report raised against him, they then order him to be cited, and draw out a full copy of what is reported, with a list of the names of the witnesses to be produced for proving the allegation. He is then formally summoned to appear before them ; and he has notice served upon him, at least ten days before the time of his appearance, to give in his answers to what is termed the *libel*. If at the time appointed the minister appear, the libel is read to him, and his answers are also read. If the libel be found relevant, then the presbytery endeavours to bring him to a confession. If a minister absent himself by leaving the place, and prove contumacious, without making any relevant excuse, a new citation is given him, and intimation is made at his own church when the congregation is met, that he is to be holden as confessed, since he refused to appear before them ; and accordingly he is deposed from his office.

FAME, a heathen goddess, celebrated chiefly by the poets. She is feigned to have been the last of the race of Titians produced by the earth, to have had her palace in the air, and to have possessed a vast number of eyes, ears, and tongues. She is mentioned by Hesiod, and particularly described by both Virgil and Ovid.

FAMIA, or Famieh, a town of Syria, the ancient Apamea. Here, under the rule of the Seleucidæ, was a school and nursery for cavalry, where 30,000 horses and 500 elephants were fed. There are now only a few buffaloes and sheep. It is thirty miles north of Damascus. Long. 36. 43. E. Lat. 35. N.

FAMILIARS of the Inquisition, persons who assist in apprehending such as are accused, and carrying them to prison. They are assistants to the inquisitor, and called *familiars*, because they belong to his family. In some provinces of Italy they were called *cross-bearers*, in others the *scholars of St Peter the Martyr*; and they wore a cross in front on the outside of the garment. They are properly bailiffs of the inquisition; and the office is esteemed so honourable, that in Portugal noblemen have been ambitious of belonging to it.

FAMILY denotes the persons who live together in one house, under the direction of one head or chief manager. It also signifies the kindred or lineage of a person; and is used by old writers to indicate a hide or portion of land sufficient to maintain one family.

Family, in *Natural History*, a term used to express any order of animals, or other natural productions, which exhibit certain affinities, or the same characters.

Family Islands, a cluster of small islands near the north-east coast of New Holland, and twelve miles northwest of Cape Sandwich.

FAN, a machine employed to produce coolness by agitating the air. That the use of the fan was known to the ancients is very evident from what Terence says:

> Cape hoc *flabellum*, et ventulum huic sic facito;

and also from the words of Ovid,

> Profuit et tenues ventos movisse *flabello*.

The fans of the ancients were made of various materials; but the most elegant were composed of peacocks' feathers, or perhaps painted so as to represent these.

In the Greek church, a fan is put into the hands of the deacons in the ceremony of their ordination, in allusion to a part of the deacon's office in that church, which is to keep the flies off the priests during the celebration of the sacrament.

What is called a *fan* amongst us is a thin skin, or piece of paper, taffety, or other light stuff, cut semicircularly, and mounted on several little sticks of wood, ivory, tortoise-shell, or the like.

Fan is also an instrument used to winnow corn. The machine employed for this purpose by the ancients seems to have been of a form similar to ours. The fan, which Virgil calls *mystica vannus Inachi*, was used at initiations into the mysteries of the ancients. For as the persons who were initiated into any of the mysteries required to be particularly good, the instrument which separates the wheat from the chaff was a fit emblem of setting apart the good and virtuous from the vicious and useless part of mankind.

FANATICS, enthusiastic, visionary persons, who pretend to revelation and inspiration. The ancients called those *fanatici* who passed their time in the *fana* or temples, and being often seized with a kind of enthusiasm, as if inspired by the divinity, showed wild and antic gestures. Prudentius represents them as cutting and slashing their arms with knives.

FANCY. See Imagination.

FANIONS, in the military art, small flags carried along with the baggage.

FANNERS, a machine for winnowing corn, or for separating the chaff from the grain. See Agriculture.

FANO, a city of the delegation Urbino, in the papal dominions, in Italy. It is situated on an arm of the river Metauro, on the sea shore, is surrounded with walls, and contains a cathedral, sixteen parish churches, nine monasteries, and five nunneries, a large opera house, and many handsome private houses, with a population of 14,670 persons, who depend for subsistence on the various branches of the silk trade, and on the fishery from its port. Long. 12. 54. 33. E. Lat. 43. 51. N.

FANSHAWE, Sir Richard, a distinguished cavalier in the heroic age of the civil wars and the protectorate, was the youngest son of Sir Henry Fanshawe, brother of Lord Viscount Fanshawe of Dromore in Ireland, and born at Ware-park, Hertfordshire, in June 1608. He had only attained his seventh year at the time of his father's death, when the care of his education devolved on his mother, who placed him under the celebrated schoolmaster Thomas Farnaby, and, in due time, sent him to Cambridge, where he was admitted as a fellow-commoner of Jesus College in November 1623. Having prosecuted his studies with success, and, in particular, discovered a taste for classical learning, he was, in January 1626, removed to the Inner Temple; but at his mother's death, which happened soon afterwards, he resolved to pursue a line of life more congenial to his inclination, and, with this view, he visited France and Spain, where, in the course of his travels, he acquired the languages and studied the manners and institutions of those countries. On his return to England he was appointed secretary of legation to the embassy at Madrid, whither he immediately repaired, and was left as chargé d'affaires at the Spanish court from the time of Lord Aston's resignation till the appointment of Sir Arthur Hopton as his successor in 1638.

On the breaking out of the civil war, Fanshawe, being then in England, declared at once for the king, and was entrusted with several important employments. In 1644, whilst attending the court at Oxford, he was made secretary to the Prince of Wales, whom he accompanied in his expedition to the western parts of England, and thence to the islands of Scilly and Jersey. In 1648, he was appointed treasurer of the navy under Prince Rupert, an office which he held till 1650, when he was created a baronet, and sent to Madrid to represent the necessitous condition of the king his master, and to implore assistance from Philip IV. Recalled to Scotland, where Charles II. had now made his appearance, he served there in the capacity of secretary of state, but without taking either the covenant or the engagement; and being recommended by the king to the York party, he was received with great kindness by the latter, and entrusted with the broad seal and signet. In 1651, Sir Richard was taken prisoner at the battle of Worcester, conveyed thence to London, and there committed to close custody; but having contracted a dangerous illness, he was liberated on giving bail to the amount of four thousand pounds, chiefly, as would appear, through the intercession and influence of Cromwell. In 1654, we find him at Tankerley-park, which he had hired of his friend Lord Strafford, to whom he dedicated his translation of the *Lusiad* of Camoens, written during his residence there. Early in 1659, he obtained the discharge of his bail, on pretence of going abroad with the eldest son of the Earl of Pembroke, and immediately repaired to Breda, where Charles II. received him with open arms, knighted him, and appointed him master of requests and Latin secretary.

On the restoration, Sir Richard expected, from a promise which had been formerly made to him, to be appointed secretary of state; but, through the paramount influence of Monk, Duke of Albemarle, the office was conferred on a creature of his own, Sir William Morrice. "The king," says Lady Fanshawe, in her *Memoirs*, "promised Sir Richard that he should be one of the secretaries of state, in the event of his restoration, and both the Duke of Ormond and Lord Chancellor Clarendon were witnesses to it; but that false man (Monk) made the king break his word for his own accommodation, and placed Mr Morrice, a poor country gentleman of about L.200 a year, a fierce presbyterian, and one who never saw the king's face; but still promises were made of the reversion to Sir Richard." In the parliament which met on the 8th May 1661, he took his seat as one of the representatives of the university of Cambridge, and was soon afterwards sworn a privy counsellor for Ireland. He was then sent as envoy extraordinary to Portugal; and being shortly afterwards appointed ambassador to the court of that country, he negotiated the treaty of marriage between Charles II. and the Infanta Donna Catharina, daughter of John VI. and returned to England towards the close of the year. In 1662 he was again sent as ambassador to the court of Lisbon, and, on his return to England the following year, was sworn a member of the privy council. Being considered by the king of Portugal as the fittest person to bring about an accommodation between that country and Spain, Sir Richard was, in the beginning of 1664, sent as ambassador to the court of Philip IV. by whom he was received with the most flattering marks of distinction, under the impression, as appears, that he was authorized, on the part of England, to give up Tangier and Jamaica to Spain. The Spaniards, however, finding themselves disappointed in this expectation, altered their tone; and cordiality having given place to coldness and distrust, the ambassador found himself exposed to frequent mortifications, and involved in the greatest perplexities. At the earnest desire of Spain he had made a journey to Lisbon, for the purpose of endeavouring to bring about an accommodation with Portugal, but returned without effecting any thing. At length, however, when the life of Philip IV. appeared to be drawing towards a close, a project of a treaty, containing greater commercial advantages, and insisting on fewer inconvenient conditions, than any that had formerly been proposed, was suddenly submitted to him, accompanied with an urgent demand of immediate acceptance or rejection, on account of the king's illness, which, it was alleged, might be followed by an entire change in the Spanish councils. In this emergency, the ambassador, after comparing the project with his instructions, and suggesting certain additions and modifications, which were agreed to, consented to sign the treaty, to which was annexed a secret article respecting Portugal, and immediately transmitted it to England. But objections having been taken to it in council, chiefly on the ground that the ambassador had exceeded his powers, the king was advised to withhold his ratification, and Sir Richard was in consequence recalled. But whilst he was preparing to return home, he was, on the 4th of June 1666, seized with a violent fever, which put an end to his life, at Madrid, on the 16th of the same month, the very day on which he had intended to take his departure for England.

Sir Richard Fanshawe was married in Wolvercot church, near Oxford, on the 18th May 1644, to a daughter of Sir John Harrison, by whom he had six sons and eight daughters, of whom only one son and four daughters survived him. Lady Fanshawe was related to her husband, inasmuch as her mother was daughter to Robert Fanshawe, Esq. of Fanshawe-gate, grand-uncle to Sir Richard. She is also the author of *Memoirs* which she composed for the use of her only surviving son, and which, besides many traits of natural feeling and noble sentiment, contain a very interesting account of the losses and sufferings of the Fanshawe family in the royal cause, and more particularly of the proceedings of her husband, Sir Richard, to whom she seems to have been most affectionately attached, and of whom, from the time of their marriage, she was the constant companion, amidst all the difficulties and perils of those troubled times. For a very judicious and discriminating notice of these *Memoirs* the reader is referred to the *Edinburgh Review* (vol. l. p. 75.)

Although much of Sir Richard Fanshawe's life was spent in active employment, he found leisure to produce the following works: 1. An English translation, in verse, of Guarini's *Pasto Fido*, 1646, in 4to; 2. A translation from English into Latin verse of Fletcher's *Faithful Shepherdess*, 1658; 3. An Ode on the king's proclamation in 1630, an English translation of the fourth book of the Æneid, Odes of Horace translated into English, and a Discourse of the Civil Wars of Rome, inserted in the octavo edition of the *Faithful Shepherdess;* 4. A translation of the *Lusiad* of Camoens, 1655, in folio; 5. Two pieces, entitled, *Querer per solo querer*, published after his decease, 1671, in 4to, and *Fiestas de Aranjuez*, both written by Antonio de Mendoza in 1623, and translated into English by Sir Richard in 1654; 6. Correspondence, entitled *Original Letters of his Excellency Sir Richard Fanshawe, during his Embassy in Spain and Portugal.*

FANTASIA, in the Italian music, signifies *fancy*, and is used for a composition, in which the composer ties himself to no particular time, but ranges according as his fancy, amidst various movements and different airs, dictates. This is also called the capricious style. Before sonatas were used, many compositions of this kind appeared, some of which even now remain.

FANUM, among the Romans, a temple or place consecrated to some deity. The deified men and women among the heathens had likewise their *fana;* and Cicero even erected one to his daughter Tullia.

FARAHA, a town of Arabia, on the south coast of the Persian Gulf, 200 miles east-south-east of El Catif. Long. 51. 30. E. Lat. 25. 7. N.

FARANDMAN, a traveller, or merchant stranger, to whom, by the laws of Scotland, justice ought to be done with all expedition, that his business or journey be not hindered.

FARCE was originally a droll petty show or entertainment, exhibited by charlatans, and their buffoons, in the open street, in order to gather the crowd together. The word is French, and signifies, literally, forced meat or stuffing. It was applied on this occasion on account of the variety of jests, gibes, and tricks, with which the entertainment was interlarded. Some authors derive the word farce from the Latin *facetia;* others from the Celtic *farce*, mockery; and others from the Latin *farcire*, to stuff.

Modern dramatists have reformed the wildness of the primitive farces, and brought them to the taste and manner of comedy. The difference between the two on our stage is, that comedy keeps to nature and probability; whereas farce disallows all laws, or rather upon occasion sets them aside. Its end is purely to excite mirth; and it sticks at nothing which may contribute thereto, however wild and extravagant. Hence the dialogue is usually low, the persons of inferior rank, the fable or action trivial or ridiculous, and nature and truth everywhere heightened and exaggerated, to afford the more palpable ridicule. See DRAMA.

FARDAPOOR, a town of Hindustan, in the province of Berar. The fort is of no strength. It is forty-three miles north-west of Jalnapoor. Long. 76. 12. E. Lat. 20. 29. N.

FAREHAM, a market-town of the county of Southampton, in the hundred of its own name, seventy-two miles from London. It stands nearly at the head of Portsmouth harbour, and vessels of considerable burden can discharge their cargoes there. It is resorted to in the summer for the purpose of sea-bathing. There is a corporation who regulate the local business of the town. The market is held on Wednesday. The inhabitants amounted in 1801 to 3030, in 1811 to 3225, in 1821 to 3677, and in 1831 to 4402.

FAREWELL Cape, on the north-west coast of Tavai Poenammoo, the southern island of New Zealand. Long. 186. W. Lat. 40. 33. S.

FARLEU, money paid by the tenants in the west of England, in lieu of a heriot. But in some manors of Devonshire, farleu is often distinguished as the best goods, whilst heriot is the best beast, payable at the death of a tenant.

FARM, Farin, or *Ferm* (*Firma*), in *Law*, signifies a little country messuage or district, containing house or land, with other conveniences, and which is hired or taken by lease, at a certain yearly rent. See Agriculture.

In the corrupted Latin, *firma* signified a place inclosed or shut in; and hence, in some provinces, as Ménage observes, they call *closerie*, or *closure*, what in others they call a *farm*. We also find *locare ad firmam*, signifying to let to *farm*; probably on account of the sure hold the tenant here has in comparison of tenants at will.

Spelman and Skinner, however, chuse to derive the word *farm* from the Saxon *fearme*, or *feorme*, that is, *victus*, provision; by reason of the country people and tenants having anciently paid their rents in victuals and other necessaries, which were afterwards converted into the payment of a sum of money. Hence a *farm* was originally a place which furnished its landlord with provisions. Amongst the Normans, farms which pay in kind, that is, in provisions, and those which pay in money, are still distinguished; the former being simply called *fermes*, and the latter *blanche ferme*, or white farm.

Spelman shows, that the word *firma* anciently signified not only what we now call a *farm*, but also a feast or entertainment, which the farmer gave the proprietor or landlord, during a certain number of days, and at a certain rate, for the lands held of him. Thus *fearme* in the laws of King Canute has been rendered *victus*; and thus also we read of *reddere firmam unius noctis*, and *reddebat unum diem de firma*, denoting provision for a night and day. About the time of the conquest rents were all paid in provisions; a custom which is said to have been first altered under King Henry I. We also speak of *farming* duties, imposts, and the like.

FARMER, he who tenants a farm, or is lessee thereof; and generally every lessee for life, years, or at will, is called *farmer*. As this word implies no mystery, except it be that of husbandry, husbandman is the proper addition for a farmer.

Farmer, *Hugh*, an English clergyman and a man of letters, belonging to the protestant nonconformists, was descended from people of respectability in North Wales, and first drew breath at Shrewsbury, in the year 1714. Dr Charles Owen was for some time his tutor; but previously to the period when he was under that master, he had been at a school in Llanegrin. His parents from the first having designed him for the ministry, he was in 1730 sent to prosecute his studies under Dr Doddridge at Northampton. Here, by the rectitude of his conduct and wonderful proficiency, he gained the esteem of that excellent person, who always spoke of him in the most respectful terms. Having completed his academical studies, Mr Farmer became the chaplain of William Coward, Esq. of Walthamstow, in the county of Essex, and was at the same time chosen minister of a dissenting congregation in that village. But notwithstanding the gratitude with which Mr Coward deserves to be remembered by many for his charitable institutions, he had certain peculiarities of temper which rendered him a very disagreeable companion. His doors were shut at an uncommonly early hour of the night, and neither visitor nor resident could afterwards obtain admission. Mr Farmer having one evening been detained a little beyond that hour, found the doors shut against him, and was under the necessity of applying to a Mr William Snell, solicitor, a man of eminence, and possessed of many excellent qualifications. In the family of this gentleman he remained for about thirty years, living in the greatest friendship and intimacy. Here also he gradually prepared those valuable treatises and dissertations which were afterwards given to the public, and which acquired him so much celebrity as a man of letters. He likewise continued to discharge the duties of his ministerial function to the people of Walthamstow.

When a day of thanksgiving was appointed for the suppression of the rebellion in 1745, Mr Farmer preached a sermon on that occasion, which was published the following year. His next work was of much greater importance, being entitled, An Inquiry into the Nature and Design of our Lord's Temptation in the Wilderness. In this production it was the design of Mr Farmer to prove that the whole was transacted in vision, the different stages of which were intended to point out to him the difficulties and duties of his subsequent ministry. The originality of thought and profound erudition which this work displayed, soon obtained for it a very extensive circulation, and called forth the exertions of those who were of an opposite opinion. It received one reply under the title of Christ's Temptations real Facts, which possessed considerable merit, but was much inferior to Mr Farmer's in energy of expression, depth of thinking, and force of argument. But the most masterly, perhaps, of all Mr Farmer's literary productions was his Dissertation on Miracles, designed to show that they are arguments of a divine interposition, and absolute proofs of the mission and doctrine of a prophet; a work which was first published in the year 1771. But as great talents are frequently envied, so this work of Mr Farmer was declared by some to have been chiefly borrowed from Lemoine's treatise on the same subject; slander which he refuted in a very able and satisfactory manner. In the year 1775 he published his celebrated Essay on the Demoniacs of the New Testament, which may be considered as the completion of the design he had in view by his dissertation on miracles. The hypothesis which he adopted had formerly been defended with great ability by Mede, Sykes, Lardner, and others; but it was reserved for the critical acuteness of Mr Farmer to free it from those difficulties with which it was surrounded, and to place the subject in a much clearer light. His essay on demoniacs was successively attacked by Dr Worthington and Mr Fell, both of them men of considerable erudition, but much inferior in ability to their antagonist.

Mr Farmer having continued for several years the sole pastor of the congregation at Walthamstow, an able colleague was appointed him in 1761, in consequence of which he became the afternoon preacher to the congregation of Salter's Hall, in the city of London, and soon afterwards the Tuesday lecturer at the same place. But he resigned his ministerial employments as he advanced in years, a circumstance which the people committed to his charge very much regretted. In the year 1785 an affection in his eyes nearly deprived him of sight, but by means of a surgical operation he was for some time enabled to resume his studies. Mortality is, however, the inevitable lot of all men, and in 1787 the growing infirmities of Mr Farmer brought him to the grave, in the seventy-third year of his age.

Farmer, *Richard*, D. D. a scholar and critic of considerable eminence, was the son of a hosier at Leicester, at which place he was born in the year 1735. Here he received the rudiments of his education, and afterwards became a student at Cambridge, and pensioner of Emanuel College. He was considered as a young man well acquainted with books, much esteemed among his friends, and looked upon as possessed of lively parts, even before he had acquired any extraordinary reputation as a scholar. He was made bachelor of arts in 1757, and master of arts in 1760. Several years after this period, having been for some time a curate, he took the degree of bachelor in divinity, and became a preacher at Whitehall. Besides the attention he paid to the Greek and Roman authors, he prosecuted the study of books in his own language, printed in black letter, and thus laid the foundation of a work which added more to his literary reputation than any other performance. This was an Essay on the Learning of Shakspeare, which he published in 1766. Men of letters had long turned their attention to the learning of Shakspeare, in order to ascertain its real extent. It could not be questioned that he was acquainted with the history and mythology of the ancients, but it was still a matter of dispute from what sources that acquaintance had been derived. To obviate this difficulty, Mr Farmer's knowledge of books enabled him to demonstrate, that translations of the far greater part of the classical authors were to be met with in the time of our distinguished dramatist; and as he showed that Shakspeare had even copied the blunders and errors of these translations, he made it manifest beyond the possibility of a rational doubt, that he was wholly incapable of consulting the originals. This essay passed through three editions in a very short time, and was much admired for the sprightliness of its composition, whilst the readers of it were in general persuaded that he had fully established his point.

This performance brought him into notice, and became extremely favourable to his professional advancement. By the influence of Bishop Hurd, he procured the chancellorship and a prebend in the cathedral of Lichfield; and in 1775 he was elected master of Emanuel College, and took the degree of doctor in divinity. He was soon afterwards appointed principal librarian to the university, and served in turn the office of vice-chancellor. He was made prebendary of Canterbury by Lord North, at that time prime minister, and Mr Pitt twice offered him a bishopric; but the constraints and solemnity of the episcopal character were not congenial to his natural temper, on which account he declined the offer, and having resigned his office as prebendary, he accepted of a residentiaryship of St Paul's. This obliged him to reside three months annually in London, which he spent with equal pleasure and advantage in the society of literary men. From nature he inherited a fund of good humour, and was of such an obliging turn, that he buried party spirit in the satisfaction which he found in the performance of beneficent actions. Though in general an enemy to reforms of every kind, and anxious to preserve things as they were, both in church and state, he was nevertheless instrumental in amending the police of Cambridge, especially as it related to the paving and lighting of the streets. At his instigation also, monumental sculpture was admitted into the cathedral of St Paul's, and will continue to exhibit a striking proof of national gratitude, as well as serve to cover the nakedness of the walls.

It was at one time the intention of Dr Farmer to publish a history of the town and antiquities of Leicester; but either his independent circumstances, or a degree of native indolence, made him relinquish the design, and the few materials which he had collected were therefore given to Mr John Nichols, at that time engaged in an elaborate work on the same subject. After a painful illness of some length, Dr Farmer died at Emanuel College in the month of September 1797, in the sixty-second year of his age. Dr Parr wrote an epitaph for his tombstone, in which we find the following testimony to his worth: *Vir facetus et dulcis, festique sermonis, Græce et Latine doctus, in explicanda veterum Anglorum poesi subtilis et elegans.*

FARNABIE, Thomas, son of a carpenter in London, and born in 1575, staid a short time at Oxford, where being enticed to abandon his religion, he went to Spain, and was there educated in a college belonging to the Jesuits. Being weary of their severe discipline, he accompanied Sir John Hawkins and Sir Francis Drake in their last voyage in 1595. He was afterwards a soldier in the Low Countries; but being reduced to great want, he returned to England, where, wandering about for some time under the name of Thomas Bainrafe, the anagram of his name, he settled at Mattock in Somersetshire, and there taught a grammar school with good reputation. He afterwards removed to London, and opened a school with large accommodations for young gentlemen. Whilst he taught this school, he was made master of arts at Cambridge, and incorporated into the university of Oxford. In 1636, he removed to Seven Oaks in Kent, and taught the sons of several noblemen and gentlemen, who boarded in his house, with great success, and grew rich. His works gained him reputation. Upon the breaking out of the civil commotions in 1641, he was cast into prison, and it was debated in the House of Commons whether he should be sent to America; but this motion being rejected, he was removed to Ely House, in Holborn, where he died in the year 1647. Farnabie was a very eminent grammarian; and many writers have spoken with great approbation of his labours. Mr Bayle in particular says, "His notes upon most of the ancient Latin poets have been of very great use to young beginners; being short, learned, and designed chiefly to clear up the text."

FARNHAM, a market-town at the western end of the county of Surrey, in the hundred of the same name, 41 miles from London, on the road to Portsmouth. The vicinity is chiefly remarkable for the quality of the hops produced, which by their celebrity, and consequently high price, have extended the cultivation very considerably. There is an ancient castle transformed into a palace, the residence of the Bishop of Winchester. The making of worsted hose, which once flourished, has now disappeared. The market is held on Thursday, and the sale of wheat at it is extensive. The population amounted in 1801 to 2508, in 1811 to 2911, in 1821 to 3132, and in 1831 to 3142.

FARNOVIANS, in *Ecclesiastical History*, a sect of Socinians, so called from Stanislaus Farnovius, who separated from the other Unitarians in the year 1568, and was followed by several persons eminent for their learning. This sect did not last long; for having lost their chief, who died in 1615, it was scattered abroad and reduced to nothing. Farnovius was engaged by Gonesius to prefer the Arian system to that of the Socinians; and consequently asserted that Christ had been produced out of nothing by the Supreme Being, before the creation of this terrestrial globe. His sentiments concerning the Holy Ghost are not certainly known; but it appears that he warned his disciples against paying the tribute of religious worship to the Divine Spirit.

FARNWORTH, a township of the county of Lancaster, within the parish of Dean, occupied chiefly by manufacturers of cotton goods, whose numbers amounted in 1801 to 1439, in 1811 to 1798, in 1821 to 2044, and in 1831 to 2928.

FARO, a city on the sea coast, in the province of Algarve, in Portugal, in lat. 37. 2. N. It is a little to the westward of Cape Santa Maria, and only admits ships to enter or depart at spring tides. It has some trade with the north of Europe, to which it exports figs, resins, oranges, lemons, olives, and almonds, cork, sumach, and ropes and cords of esparto and the tunny fish. The streets of this town are broad and regularly built, and it contains a cathedral, 927 houses, and 6025 inhabitants.

FAROE, Faroer, or Feroe, a group of European islands, situated in the Northern Ocean, between Zetland and Iceland, about 200 miles north-west of the former. They appear to form the country described by the early Venetian navigators under the name of Friesland, though that term was afterwards applied by the English to the northern extremity of Greenland. These islands are twenty-two in number, of which the principal are Stromoe, Osteroe, Suderoe, Wangoe, and Sandoe. They consist throughout of rocks and hills, rising to a considerable height, and separated from each other by narrow valleys, or rather ravines. Although, however, these hills rise abruptly, there are often on their summits, or at different stages of their ascent, plains of considerable magnitude. They everywhere present to the sea perpendicular cliffs, broken into a thousand fantastic forms, and which, to those who sail along the coast, present at every turn the most picturesque and varied scenery. The highest peak is that of Skellingfell, in the island of Stromoe, which is supposed to rise about 3000 feet above the sea. The rocks consist generally of trap, and exhibit little variety of composition, though they present some striking geological phenomena. The zeolites and chalcedonies here collected have long supplied the best specimens of these minerals to the cabinets of Europe.

The population of the Faroe Islands, according to a statistical table drawn up in 1812, amounted to 5209. Agriculture is in a very imperfect state, the infield, or cultivated land, being supposed to bear to the outfield, or uncultivated, the proportion of one to sixty. The plough is scarcely ever used, being in fact ill suited to the rugged and uneven surface of which all the islands consist. The ground is therefore turned up with the spade, care being taken not to destroy the roots of the grass. Horses and cows are few in number, and the latter give very little milk, in consequence, probably, of the very coarse hay upon which they are fed. Sheep form the chief riches of the islanders, and the number possessed by them was calculated in 1812 at 35,307. Some individuals have flocks of two or three hundred. These sheep are allowed to run about, both in summer and winter, without ever being housed, and in severe seasons they suffer considerably. The wool is generally coarse, and is torn off the animals in so rough a manner, as often to lacerate the skin. The fishery, which was once considerable, has been neglected, and is now of little consequence. The catching of the numerous birds which build their nests upon the face of the cliffs, forms a great source of subsistence to the inhabitants. Those persons employed in this hazardous trade display great ingenuity and the most adventurous spirit. Sometimes the fowler is let down from the top of the cliff by a rope fastened to his waist; at other times, where there is any footing at all, he climbs the steepest rocks, or, where that is impossible, has himself thrust up by poles made for the purpose. The puffin (*Alca Arctica*) is the most common of these birds, and the eider duck is here often shot for food.

The Danish government has given the monopoly of the trade of the Faroe Islands to a mercantile house at Copenhagen, under the condition of supplying the inhabitants with a sufficient quantity of grain at a constant fixed price. Should the market price be such as to render this a losing transaction, the merchant is indemnified by government. This care of provisioning the islands is probably superfluous; and the natural bad effects of a monopoly are felt in the high price of other imported articles, a good jacket being often given for a few leaves of tobacco. The exports consist of hose knit on the islands, to the annual amount of 100,000 pairs; tallow, fish, train-oil, feathers, skins, and butter. During the war between Britain and Denmark, the Fort of Thorshaun was, in 1808, destroyed by Captain Baugh, lest it should afford harbour to privateers. A German adventurer, who assumed the name of Baron Hompesch, afterwards landed and plundered the place; but his conduct was disavowed by the British government, who even restored the value of the property of which the natives had been robbed. Finding also, that the people having lost their communication with Denmark, were in danger of suffering from famine, Britain permitted a limited intercourse to be carried on, under license, from Leith. But the peace restored all things to their usual channel.

Thorshaun, the principal place in the country, does not contain above 520 inhabitants. It is situated on the eastern coast of the island of Stromoe, upon a narrow tongue of land, having creeks on each side, where ships may be safely moored. The houses are built of wood, and roofed with birch bark covered with turf; the greenness of which makes it impossible, at a very short distance, to distinguish the place from the surrounding fields. The character of the people is generally marked by great simplicity of manners, kindness, and hospitality. (See *A Description of the Faroe Islands;* by the Rev. G. Landt; translated from the Danish; London, 1810. *An Account of some Geological Facts observed in the Faroe Islands;* by Sir George Stewart Mackenzie, Bart. in the *Transactions of the Royal Society of Edin.* vol. vii. *An Account of the Mineralogy of the Faroe Islands;* by Thomas Allan, Esq. *ibid.*)

FARQUHAR, George, a celebrated comic writer, was the son of a clergyman, and born in 1678 at Londonderry, in Ireland, where he received the rudiments of his education, and gave early indications of that genius for which he afterwards distinguished himself. As he was one of a numerous family, his parents, having no fortune to leave to their children, resolved to give him the compensatory benefit of a liberal education; and, with this view, young Farquhar, as soon as he was qualified for the university, was sent to Trinity College, Dublin. This took place in 1694. At first our youth Farquhar made great progress in his studies, and even acquired considerable reputation; but at length the retirement and restraint of a college life proving distasteful to him, he quitted Trinity, where he found himself incapable of seeking advancement by the slow and regular progression of university degrees; and betaking himself to the stage, he obtained admission into the company of the Dublin theatre. Though his voice was somewhat weak, he had the advantage of a good person, which, with his evident talents, ensured him a favourable reception as an actor; and he resolved to continue on the boards until something better should present itself for his acceptance. But an accident of rather a serious kind put an end to this resolution, and suddenly altered the whole complexion of his life. Being to play the part of Guyomar in Dryden's *Indian Emperor,* and having forgotten to blunt his sword, or exchange it for a theatrical rapier, Farquhar, in the scene where Guyomar is supposed to kill the Spanish general Vasquez, run through the body his brother tragedian who represented that part. The poor general of the scene believed himself killed in good earnest, but happily the wound, though dangerous, did not prove mortal. Farquhar, however, was so shocked at the occurrence, that he quitted the stage, determined never again to expose himself to the risk of such accidents. But this histrionic essay had been sufficient to form his taste and develope his talents for dramatic literature.

Having now no inducement to remain at Dublin, Farquhar proceeded to London, where, in 1696, Wilks the actor, knowing his humour and abilities, prevailed on him to write a play, at the same time assuring him that he was generally considered as better qualified to furnish compositions for the stage than to act a part in those of other writers. His first comedy, called *Love in a Bottle*, was brought out in 1698, and well received, on account of its sprightly dialogue and busy scenes. About this time the Earl of Orrery, to whom Farquhar was already known by his literary talents, and esteemed for his character, gave him a commission as lieutenant in his own regiment, then in Ireland, in which capacity he served several years, and gave proofs both of courage and conduct. In 1700 he produced his *Constant Couple, or Trip to the Jubilee*, so called because it was then the jubilee year at Rome, whither persons of all countries flocked for indulgences and amusements. In Sir Harry Wildair he delineated a gay and airy character, so impregnated with wit and vivacity, and withal so well adapted to the peculiar talents of Wilks, that the player acquired almost as much reputation as the dramatist. Towards the close of this year Farquhar visited Holland, probably in his military capacity, and, in several letters which he wrote, gave a very humorous description of the people, and the adventures he met with, particularly of an entertainment given by the Earl of Westmoreland, whilst not only that nobleman himself, but King William and others, were detained by a violent storm. In 1701 he was a spectator, if not a mourner, at the funeral of Dryden. Encouraged by the success of his *Constant Couple*, he this year wrote a continuation of the play, called *Sir Harry Wildair, or the Sequel of the Trip to the Jubilee*, in which Mrs Oldfield, whom the author had introduced to the stage, was as greatly admired, and obtained as much reputation, in her part, as Wilks had previously done in his.

In 1702 he published his *Miscellanies*, consisting of poems, letters, and essays, all filled with humorous and pleasant sallies. Some of these letters were, it is said, published from copies returned at his request by Mrs Oldfield, to whom they had been addressed. At the end there is a *Discourse upon Comedy*, in reference to the English stage; and one of the letters contains *The Picture*, a descriptive character of the writer, in which he is represented as an ingenious, good-natured, and thoughtless person. In 1703 he brought out another comedy, entitled *The Inconstant, or the Way to win him;* but as the public taste, influenced by fashion, was now turning in favour of French and Italian operas, which have long been the bane of our native genius, this production, though not inferior in merit, was more coldly received than any of its predecessors. This year Farquhar married (as he was led to believe) a person of fortune. The lady, it seems, had fallen violently in love with him, and resolved to have him at any rate; but, knowing his habits, and aware that he was too dissipated to think of matrimony unless advantages were annexed to it, she caused a report to be circulated that she had a great fortune, and followed this up by an intimation of her love for the dramatist. Farquhar fell into the snare, and married her. But although he found himself grossly deceived, his circumstances embarrassed, and his family increasing, he, with rare magnanimity, never once upbraided his wife with the imposition she had practised on him, but behaved to her with all the delicacy and tenderness of a kind and indulgent husband.

Early in 1704, Farquhar, in conjunction with another person, produced a farce called *The Stage-coach*, which was well received. His comedy entitled *The Twin Rivals* was played in 1705, and *The Recruiting Officer* made its appearance in 1706. His last production, *The Beaux Stratagem*, was only performed a few days before his death, which happened in April 1707, but not until he had been made aware of the complete success of the comedy. *The Beaux Stratagem* is generally regarded as Farquhar's masterpiece, and, certainly, of all his plays it is that which has kept the firmest hold of the stage. The characters are said to have been drawn from living originals whom the author met with in Lichfield and its vicinity; but whether this was the case or not, he has sufficiently generalized his delineations to divest them of partial or localized distinctions, and has thus imparted to them an interest which neither time nor change of manners has in any material degree impaired. Towards the close of his life Farquhar was unhappily oppressed with debt, which obliged him to sell his commission; a circumstance which, with some collateral disappointments, preyed upon his spirits, and hurried him to a premature grave before he had attained the age of thirty. Soon after his death, the following letter, addressed to Mr Wilks the actor, was found amongst his papers: "Dear Bob, I have not any thing to leave thee to perpetuate my memory but two helpless girls; look upon them sometimes, and think of him that was to the last moment of his life, thine, George Farquhar." This affecting recommendation, resembling the testament of Eudamidas, was not lost on the generous player, who watched over the orphans of his gifted friend, and, when they came of age to be put out in the world, procured each of them a benefit to supply the means necessary for the purpose.

Of Farquhar's merits as a dramatic writer various opinions have been entertained, and different judgments consequently pronounced. It can scarcely be disputed, however, that he was commonly fortunate in the choice of his subjects, which he embellished with a great variety of characters and incidents; that his style is in general simple, unaffected, and natural; that his dialogue is full of gaiety and wit, and flows in a natural, easy current, less sparkling and brilliant than that of Congreve, but at the same time also less elaborate; and that his plots, though almost all founded on improbable or romantic suppositions, are naturally conducted, and full of amusing vivacity. He has been justly reproached with licentiousness, which, in his discourse upon comedy, he even attempts to defend; but this was the vice of the age rather than of the writer, who felt himself obliged to consult its taste, and adapt his compositions to its prevailing manners; and is certainly not less imputable to Congreve than to Farquhar. The tone of their characters, indeed, appears to have been that of the society of the time, of which these are, as it were, reflections; and hence in the comedies of both there is a relative truth, which must not be lost sight of in estimating the moral qualities of their works. The manners represented are no doubt detestable, and vice appears rampant and unblushing, without the mask of hypocrisy, which, in less degenerate times, she is compelled to assume as a reluctant homage to virtue; but these manners are real, not imaginary; and it is from such delineations alone that we can acquire accurate conceptions of the true spirit and character of the age when they were relished and applauded. Pope, it seems, used pettishly to stigmatize Farquhar as a mere farce-writer. But posterity has been more just to his merits than the Wasp of Twickenham; and his productions, with all their faults, still keep their place on the stage, and are likely to do so, as long as the redeeming attributes of wit and genius possess any attraction in scenic representation.

FARRIER, one whose employment it is to shoe horses, and cure them when diseased or lame. The term *farrier* is probably a corruption of *ferrier*, in French *ferrans*, from the verb *ferrer*, to shoe a horse; all these words being derived from the Latin *ferrum*, iron. There is no doubt that the word *farrier* was at first used to denote a person who shod horses; but as persons of this description were for a long period the only *horse-doctors*, the term was soon used in the more extensive sense of *horse-doctor* or *horse-leech;* and hence *farriery* came to signify the *art of curing the diseases of horses.*

There can be little doubt that the word *farrier* was originally spelt *ferrier* or *ferrer*, as we meet with this latter orthography in some of our older writers. Thus Blundeville, who wrote in the time of Queen Elizabeth, in his Address to the Gentlemen of England, book fourth, has the following sentence: "All horses, for the most part, do come into their decay sooner than they should do, by one of these four waies; that is to say, either for lacke of being well bred, or through the rashness of the rider, the negligence of the keeper, or else through the unskilfulnesse of the *ferrer.*" Again, the same author mentions "Martin Ghelly of Aston, called Martin Alman, chiefe *ferrer* to the queen's magistie."

Farriery, in the usual acceptation of the word, forms only a part of the more general art, which has been commonly called the *veterinary art*, by which is understood the art of medicine as applied to the inferior animals, an art which has been long called by the French *l'art vétérinaire*, or *médicine vétérinaire.* This word *veterinary* is of very ancient date, being derived from the Latin *veterinarius*, which is used by Columella to denote a *horse-doctor* or *cattle-doctor.* The term *veterinary*, being derived from *veterinus*, a softened and abbreviated form of *veheterinus*, *à vehendo*, *carrying*, is properly applicable only to beasts of burden; but *veterinary medicine* is now commonly employed in a more comprehensive sense, to denote the art of curing the diseases of *domestic animals* in general. See VETERINARY MEDICINE.

FARRINGDON, a market-town of the county of Berks, in the hundred of the same name, sixty-eight miles from London. It is finely situated on the declivity of the termination of a range of hills, at the foot of which the Thames runs, and where the ruins of an ancient castle are to be seen. It is a town of but little trade, except what arises from a good market held on Tuesday. The inhabitants amounted in 1801 to 1691, in 1811 to 1843, in 1821 to 2784, and in 1831 to 2729.

FARS, a province of Persia, bounded by Irak on the north, Kerman and Laristan on the east, Kuzistan on the west, and on the south by the Persian Gulf. This province is divided into the Germaseer and Sirhud, or the warm and the cold climates. It is in general sandy and barren, though with some considerable exceptions. The Tabris, formed by the junction, within a few miles of the town of Zeitoon, of two streams which take their rise in the mountains of Fars, is the most considerable river of the province. It divides Fars from Kuzistan, and, eight miles below the town of Endian, falls into the sea. The warm region of this district extends from the sea to the latitude of Kazeroon, and runs parallel with the gulf from the banks of the Tabris to the confines of Laristan. It is chiefly a sandy plain at the foot of the mountains, the cultivation of which depends on the periodical rains; and when these prove abundant, the country yields abundance of dry grain; but when the rains fail, which too frequently happens, a famine generally ensues. The sandy plain, or the Dushtistan as it is called, is divided into two districts, which are separated by the projecting mountain of Bung. These two districts are thinly peopled and badly cultivated; and the few mud villages which are scattered over the plain bespeak but too clearly the wretchedness and poverty of their possessors. The cold region comprehends most of the mountainous part of Fars, extending from the latitude of Kazeroon to that of the town of Yezdekhast, situated on the bed of what appears to have been formerly a river, which separates this province from Irak. The mountains are here intersected by plains, which seldom exceed eight or ten miles in breadth, whilst in length they vary from fifteen to a hundred. They are in general fertile, affording abundance of pasturage; nor are they so deficient in water as they have sometimes been represented. A few of them, such as those of Shiraz, Kazeroon, and Merdesht, are tolerably well cultivated. But they are for the most part, particularly to the northward and westward, destitute of inhabitants. It is mentioned by Kinneir, in his Geographical Memoir of the Persian Empire, that in 1809 he travelled in this country "through the most delightful valleys, covered with wood and verdure," but all was solitary, nor was the face of a human being anywhere to be seen. The country, it appears, had been possessed by a predatory tribe, who, in consequence of their licentious conduct, had been extirpated by the vengeance of the prince, and who having in consequence fled to the lofty and inaccessible mountains, lived there on the scanty fare of a sort of bread afforded by acorns, and thence sallying forth on the low country beneath, robbed and plundered the unwary traveller, sometimes extending their inroads to villages, the inhabitants of which they either murdered, or carried away captive, to be sold for slaves in an unknown and distant land. The face of the country in the eastern parts of Fars is somewhat different, being open, the plains of greater extent, and of a sandy soil, where water is not so plentiful. The great range of mountains seen from the coast is a mere elongation of the chain of Mount Tagros, which extends in a continued succession of ridges from the borders of the Persian Gulf to the Caspian Sea and the Caucasus. These hills in Fars are situated at different distances from the sea. At Bushire they are distant twenty-four miles. But towards Bunder Reig the plain becomes contracted; and a low ridge, known by the name of Kohi Bung, or the hill of Bung, and about seven or eight miles broad, suddenly projects to the south, and touching the sea, separates the district of Leerawee from that of Hiadouat. Beyond this hill, at the plain of Leerawee, the mountains are about twenty miles distant from the sea, at which distance they continue for eighteen or nineteen miles, when they again approach the south; and this branch is known by the name of Zeitoon, on turning the southern point of which they again abruptly retire to the northward; and at the port of Mashoor they are thirty miles from the sea. The principal towns of the province are Shiraz, the capital, with 40,000 inhabitants; Bushire, the chief port in the Persian Gulf; Darabjerb, Bebahan, and some others. Within its confines also are the ruins of the cities of Shapoor and Persepolis; the latter containing some magnificent remains of antiquity.

FARTACH, or FARTAK, a sea-port of Arabia, in the province of Hadramaut, belonging to the sheik of Keshun. It is 133 miles south-east of Hadramaut, and 480 east of Mocha.

FARTHING, a small English copper coin, amounting to one-fourth of a penny. It was anciently called *fourthing*, as being the fourth of the integer or penny.

Farthing of Gold, a coin used in ancient times, containing in value the fourth part of a noble, or 20d. in silver. It is mentioned in the statute 9 Henry V. cap. 7, where it is enacted that there shall be good and just weight of the noble, half noble, and farthing of gold.

Farthing of Land seems to differ from *farding-deal* For in a survey-book of the name of West Hapton, in Devonshire, there is an entry thus: A. B. holds six farthings of land at L.126 per annum. So that the farthing of land must have been a considerable quantity, indeed far more than a rood.

FASCES, in Roman antiquity, axes bound together with rods or staves, and borne before the Roman magistrates as a badge of their office and authority. According to Florus, the use of the fasces was introduced by the elder Tarquin, the fifth king of Rome; and they were then the mark of the sovereign dignity. In after times they were borne before the consuls by turns, who had each twelve, borne by as many lictors. These fasces consisted of branches of elm, with a *securis* or axe in the middle, the head of which projected beyond the rest. But Publicola took the axe out of the fasces, as Plutarch assures us, in order to remove all occasion of terror. After the consuls, the prætors assumed the fasces. In the government of the decemvirs, it was the practice at first for only one of their number to have the fasces borne before them; but afterwards each had twelve, after the manner of the kings. When the magistrates, who by right had the axes carried before them, intended to show deference to the people, or some person of singular merit, they either sent away the lictors, or commanded them to lower the fasces, which was denominated *submittere fasces*. Many instances of this occur in Roman history.

FASCETS, in the art of making glass, are the irons thrust into the mouths of bottles, in order to convey them to the annealing tower.

FASCIA, in *Antiquity*, a thin sash which the Roman women wrapped round their bodies next to the skin, in order to make them slender. Something of this sort seems also to have been in use amongst the Grecian ladies.

Fascia, in *Architecture*, signifies any flat member having considerable breadth and but small projection, as the band of an architrave, larmier, and the like. In brick buildings, the juttings out of the brick beyond the windows in the several stories except the highest are called *fascias* or *fasciæ*.

FASCINATION, from the Greek βασκαινειν, to *fascinate* or *bewitch*, a sort of witchcraft supposed to operate either by the eye or the tongue. Ancient writers distinguish two sorts of fascination; one performed by looking, or the efficacy of the eye, and the other by words, especially by malignant praises.

Fascination of serpents, a faculty which these animals are supposed to possess of attracting birds from the air, and making prey of them.

FASCINES, in *Fortification*, are a kind of faggots made of small branches of trees or brushwood, tied in three, four, five, or even six places, and are of various dimensions, according to the purposes to which they are to be applied. Those which are to be pitched over, for burning lodgments, galleries, or any other works of the enemy, should be one and a half or two feet in length; but those which are intended to form epaulements or chandeliers, to raise or fill up ditches, are made from six to ten feet in length, and from one foot to one and a fourth in thickness. Fascines are made in the following manner: Six small pickets are stuck into the ground, two and two, forming little crosses well fastened in the middle with willow bindings; on these trestles the branches are laid, and bound round with withes at every two feet. Six men are employed in making a fascine; two cut the boughs, two gather them, and the remaining two bind them. These six men can make twelve fascines every hour.

FAST, in general, denotes abstinence from food; but is more particularly used for such abstinence on a religious account.

Religious fasting has been practised by most nations from the remotest antiquity. Some divines even pretend that it had its origin in the earthly paradise, where our first parents were forbidden to eat of the tree of knowledge. But though this seems carrying the matter too far, it is certain that the Jewish church has observed fasts ever since its first institution. Nor were the neighbouring nations, the Egyptians, Phœnicians, and Assyrians, without their fasts. The Egyptians, according to Herodotus, sacrificed a cow to Isis, after having prepared themselves by fasting and prayer; a custom which he likewise ascribes to the women of Cyrene. Porphyry affirms, that the Egyptians, before their stated sacrifices, always rested a number of days, sometimes even of weeks; and that during this time the priests and devotees not only abstained from flesh, fish, wine, and oil, but even from bread, and some kinds of pulse. These austerities were communicated by them to the Greeks, who observed their fasts much in the same manner. The Athenians had the Eleusinian and Thesmophorian fasts, the observance of which was very rigorous, especially amongst the women, who spent one whole day sitting on the ground in a mournful dress, without taking any nourishment. In the island of Crete, the priests of Jupiter were obliged to abstain during their whole lives from fish, flesh, and baked meats. Apuleius informs us, that whoever had a mind to be initiated in the mysteries of Cybele was obliged to prepare himself by fasting ten days; and, indeed, all the pagan deities, whether male or female, required this duty of those who desired to be initiated into their mysteries, of the priests and priestesses who gave out the oracles, and of those who came to consult them.

Amongst the heathens fasting was also practised before some of their military enterprises. Aristotle informs us, that the Lacedæmonians having resolved to succour a city of the allies, ordained a fast throughout the whole extent of their dominions, without excepting even the domestic animals; and this they did for two ends, first, to spare provisions in favour of the besieged, and, secondly, to draw down the blessing of heaven upon their enterprise. The inhabitants of Tarentum, when besieged by the Romans, demanded succours from their neighbours of Rhegium, who immediately commanded a fast throughout their whole territories. Their enterprise having proved successful by throwing a supply of provisions into the town, the Romans were obliged to raise the siege; and the Tarentines, in memory of this deliverance, instituted a fast to be annually observed ever afterwards.

Fasting has always been reckoned a particular duty amongst philosophers and religious people, some of whom have carried their abstinence to an incredible length. At Rome it was practised both by kings and emperors. Numa Pompilius, Julius Cæsar, Augustus, Vespasian, and others, we are told, observed stated fasts; and Julian surnamed the Apostate was so exact in this observance as to outdo the priests themselves, and even the most rigid philosophers. The Pythagoreans kept a continual lent; but with this difference, that they believed the use of fish to be equally unlawful with that of flesh. Besides their constant temperance, they also frequently fasted rigidly for a considerable time. In this respect, however, they were all outdone by their master Pythagoras, who continued his fasts for no less than fifty days together. Even Apollonius Tyaneus, one of his most celebrated disciples, could never equal him in the length of his fasts, though these greatly exceeded those of the ordinary Pythagoreans. The Gymnosophists, or Brahmins of the East, are also very remarkable for their severe fastings; and the Chinese, according to Father Lecomte, have likewise their stated fasts, with forms of prayer, for preserving them from barrenness, inundations, earthquakes, and other calamities. The Mahommedans too, who possess so large a part of Asia, are very remarkable for the strict observance of fasts; and the exactness of their dervises in this respect is extraordinary.

Fasting was often used by the heathens for superstitious purposes; sometimes to procure the interpretation of dreams; at others, to serve as an antidote against the pernicious consequences of nocturnal visions. The Jews, though expressly forbidden to fast upon Sabbath days, think themselves at liberty to dispense with this duty when they happen the night preceding to have had frightful and unlucky dreams, which they consider as presaging great misfortunes. On these occasions they observe a formal fast during the whole day; and at night the patient, having invited three of his friends, addresses himself to them seven times in a very solemn manner, saying, "May the dream I have had prove a lucky one;" and his friends answer as many times, "Amen, may it be lucky, and God make it so;" after which, in order to encourage him, they conclude the ceremony with the words of Ecclesiastes, "Go eat thy bread with joy," and then set themselves down to table. They have also added several fasts not commanded in the law of Moses, particularly three, in memory of sore distresses which their nation has at different times suffered. The abstinence of the ancient Jews commonly lasted twenty-seven or twenty-eight hours at a time, beginning before sunset, and not ending till some hours after sunset the next day. On these days they were obliged to wear white robes in token of grief and repentance, to cover themselves with sackloth, or their worst clothes, to lie on ashes, to sprinkle these on their heads, and to perform other like ceremonies. Some spent the whole night and day following in the temple or synagogue, in prayers and other devotions, barefooted, with a scourge in their hands, of which they sometimes made a good use, in order to excite their zeal. Lastly, to complete their abstinence, they were accustomed at night to eat nothing but a little bread dipped in water, with some salt for seasoning; except indeed they chose to add to their repast some bitter herbs and pulse.

The ancients, both Jews and Pagans, had also their fasts for purifying the body, particularly the priests and such as were any way employed at the altars; for when nocturnal disorders happened to them, it was unlawful to approach the altars all the next day, which they were bound to employ in purifying themselves. On this account, at great festivals, where their ministry could not be dispensed with, it was usual for them, on the eve of these solemn occasions, not only to fast, but also, for the greater certainty, to abstain from sleep. For this purpose the high priest had under officers to awake him, if overtaken with sleep, against which other preventives were also employed.

FASTERMANS, or Fasting-men, was used in our ancient customs to signify men of repute and substance; or rather pledges, sureties, or bondsmen, who, according to the Saxon polity, were bound fast to answer for one another's peaceable behaviour.

FASTI, in Roman antiquity, the kalendar in which were expressed the several days of the year, with their feasts, games, and other ceremonies.

There were two kinds of *fasti*, the greater and less; the former being distinguished by the appellation of *fasti magistrales*, and the latter by that of *fasti kalendares*. The *fasti kalendares*, which were properly and primarily called *fasti*, are defined by Festus Pompeius to be books containing a description of the whole year, that is, ephemerides, or diaries, in which the several kinds of days, *festi*, *profesti*, and *fasti*, *nefasti*, are distinguished. The author of these was Numa, who committed the care and direction of the *fasti* to the *pontifex maximus*, whom the people used to consult on every occasion. This custom continued until the year of Rome 450, when C. Flavius, secretary to the pontifices, exposed in the forum a list of all the days on which it was lawful to work; and this proved so acceptable to the people, that they made him curule ædile. The *fasti kalendares* were of two kinds, namely, *urbani* and *rustici*. The *fasti urbani*, or *fasti* of the city, were those which obtained or were observed in the city. Some are of opinion that they were thus called, because they were exposed publicly in different parts of the city; though from the various inscriptions of this kind upon antique stones, it may be conjectured that private persons had likewise *fasti* in their houses. Ovid undertook to illustrate these *fasti urbani*, and comment on them, in his *Libri Fastorum*, of which the first six books are still extant; the last six, if they were ever written, being now lost. In the *fasti rustici*, or country *fasti*, were expressed the several days, feasts, and the like, to be observed by the country people. For as the latter were occupied in tilling the ground, fewer feasts, sacrifices, ceremonies, and holidays, were enjoined on them than on the inhabitants of cities; and they had also some peculiar ones not observed at Rome. These rustic *fasti* contained little more than the ceremonies of the kalends, nones, and ides; the fairs, signs of the zodiac, increase and decrease of the days, the tutelary gods of each month, and certain directions for rustic labours to be performed each month. In the greater fasti, or *fasti magistrales*, were expressed the several feasts, with every thing relating to the gods, religion, and the magistrates; the emperors, their birthdays, offices, days consecrated to them, with feasts and ceremonies established in their honour, or for their prosperity. When flattery had at length swelled the *fasti* with a number of such circumstances, they came to be denominated *magni*, in order to distinguish them from the bare kalendar, or *fasti kalendares*.

Fasti was also a chronicle or register of time, in which the several years were denoted by the respective consuls, with the principal events which happened during their consulates. This register was denominated *fasti consulares*, or the consular *fasti*.

Fasti, or *Dies Fasti*, likewise denoted court days. The word *fasti*, *fastorum*, is formed from the verb *fari*, to speak, because during those days the courts were opened, causes might be heard, and the prætor was allowed *fari*, to pronounce the three words, *do*, *dico*, *addico*. The days in which this was prohibited were called *nefasti*.

The *dies fasti* were noted in the kalendar by the letter *F;* but it is to be observed that there were some days *ex parte fasti*, partly *fasti*, partly *nefasti*, in which justice might be distributed at certain times of the day, and not at others. These days were called *intercisi*, and were marked in the kalendar by the letters *F. P. fastos primo*, in which justice might be demanded during the first part of that day.

FASTOLF, Sir John, a renowned English officer, who served in France under Henry IV., Henry V., and Henry VI., was descended from an ancient family in Norfolk, and was born about the year 1377. He was as much distinguished for his virtue at home, as for his valour abroad; and became no less amiable in his private than he had been admired in his public character. He died in 1457, being then upwards of eighty years of age, as we learn from his contemporary William Caxton, the first English printer. By an unaccountable mistake it has been asserted, that Shakspeare's Falstaff was drawn in order to ridicule Fastolf; and this circumstance has made judicious biographers the more studious to vindicate his reputation.

FAT, an oily concrete substance, deposited in different parts of animal bodies.

Fat, in nautical language, signifies the same with broad. Thus a ship is said to have a fat quarter, if the trussing in or tuck of her quarter be deep.

Fat likewise denotes an uncertain measure of capacity. Thus a fat of isinglass contains from three and a fourth hundredweight to four hundredweight; a fat of unbound books, half a maund or four bales; of wire, from twenty to twenty-five hundredweight; and of yarn, from 220 to 221 bundles.

Fat, or Vat, is also applied to several utensils; as, a great wooden vessel, employed for measuring of malt, and containing a quarter or eight bushels; a large brewing vessel, used by brewers to run their wort in; and a leaden pan or vessel for making salt at Droitwich.

FATA Morgana, a very singular phenomenon, mentioned by different philosophical writers and travellers, who inform us that it is seen in the Straits of Messina, and sometimes denominated the *Castles of the Fairy Morgana*. The accounts of this phenomenon differ considerably from one another, and travellers are not agreed as to the causes of its production.

Minasi, in his dissertation on the *Fata Morgana*, gives a description of this remarkable phenomenon. When the rising sun shines from that point whence its incident ray forms an angle of 45° on the Sea of Reggio, and the bright surface of the water in the bay is not disturbed either by the wind or the current, whilst the spectator is placed on an eminence, with his back to the sun and his face to the sea, there appear on a sudden in the water, as in a catoptric theatre, multiplied objects, numberless series of pilasters, arches, castles well delineated, regular columns, lofty towers, superb palaces, with balconies and windows, extended alleys of trees, delightful plains with herds and flocks, armies of men on foot and horseback, and many other strange images, in their natural colours and proper actions, passing rapidly in succession along the surface of the sea during the whole of the short period of time that the above-mentioned circumstances remain as described. But if, in addition to these circumstances, the atmosphere be highly impregnated with vapour and dense exhalations, not previously dispersed by the action of the wind or waves, or rarefied by the sun, it then happens that in this vapour, as in a curtain extended along the channel to the height of from fifteen to twenty feet, and nearly down to the sea, the same objects are beheld not only reflected from the surface of the sea, but likewise in the air, though not so distinct or well defined as the former objects from the sea.

If the air be slightly hazy and opake, and at the same time dewy and adapted to form the iris, then the above-mentioned objects will appear only at the surface of the sea, as in the first case, but all vividly coloured, or fringed with red, green, blue, and other prismatic colours.

From this account, then, it appears, that there are three different species of *Fata Morgana*; the first, that which appears at the surface of the sea, being denominated the *Marine Morgana*; the second, that which is seen in the air, called the *Aerial Morgana*; and the third, that which is observed only at the surface of the sea, being the *Morgana* fringed with prismatic colours. Minasi has attempted to trace the etymology of the word *Morgana*, which, he thinks, is derived from μωρος, *tristis*, and γανοω, *lætitia afficio*. This splendid sight affects all descriptions of men with such joy, that they run towards the sea, exclaiming *Morgana, Morgana*. The etymology of Minasi, therefore, though it may at first view seem to be a contradiction in terms, will appear not unnatural, when, besides the joy which the Morgana inspires, we take into account the corresponding sorrow or dejection which must be felt when it vanishes away. The same author informs us, that he beheld this magnificent appearance three times, and would rather behold it again than the most superb theatrical exhibition in the world.

In his physical and astronomical remarks on this phenomenon, Minasi observes that the sea in the Straits of Messina exhibits the appearance of a large inclined speculum; that, in the alternate current or tide which flows and returns in the straits six hours each way, and is constantly attended by an opposite current along shore to the medium distance of about half a league, there are many eddies and irregularities at the time of the change of its direction; and that the Morgana usually appears at this period. He ascribes the effects produced by it to the supposed inclination of the surface of the sea, and its subdivision into different planes by the contrary eddies; and the effects produced in the air he considers as the result of saline and other effluvia suspended in the air. These appearances are produced by a calm sea, and one or more strata of superincumbent air differing in refractive, and consequently in reflective power, rather than from any considerable change in the surface of the water, with the laws of which we are much better acquainted than with those of the atmosphere.

To this account may be added that given by Houel, whose judgment and accuracy render his authority highly respectable. In fine summer days, says he, when the weather is calm, there arises above the great current a vapour, which acquires a certain density, so as to form in the atmosphere horizontal prisms, the sides of which are disposed in such a manner, that when they come to their proper degree of perfection, they reflect and represent successively, for some time, like a moveable mirror, the objects on the coast or in the adjacent country. They exhibit by turns the city and suburbs of Messina, trees, animals, men, and mountains; and are certainly beautiful aerial moving pictures. There are sometimes two or three prisms, equally perfect; and they continue in this state from eight to ten minutes. After this, some shining inequalities are observed upon the surface of the prism, which render confused to the eye the objects which had before been so accurately delineated, and the picture vanishes. The vapour forms other combinations, and is dispersed in air. Different accounts have been given of this singular appearance, which may perhaps be attributed to a bitumen which issues from certain rocks at the bottom of the sea, and is often seen to cover part of its surface in the Straits of Messina. The subtile parts of the bitumen being attenuated, combined, and exhaled with the aqueous globules which are raised by the air, and formed into bodies of vapour, give to this condensed vapour more consistence, and contribute, by their smooth and polished particles, to the formation of a kind of aerial crystal, which receives the light, reflects it to the eye, and transmits to it all the luminous points which colour the objects exhibited in this phenomenon, and render them visible.

FATE (*fatum*), denotes an inevitable necessity depending upon a superior cause. The word is formed *a fando*, from speaking, and primarily implies the same with *effatum*, a word or decree pronounced by God, or a fixed sentence by which the Deity has prescribed the order of things, and allotted to every person what shall befal him. The Greeks called it ειμαρμενη, as if it were a chain or series of things indissolubly linked together.

The term is also used to express a certain unavoidable destination of things, by which all agents, voluntary as well as necessary, are swayed and directed to prescribed ends. In this last sense, fate is distinguished into astrological, arising from the influence and position of the heavenly bodies, which, it was supposed, gave laws both to the elements and mixed bodies, and to the wills of men; and Stoical, defined by Cicero an order or series of causes, in which cause being linked to cause, one produces another, and thus all things flow from one prime first cause. To this fate the Stoics subject even the gods. But fate is divided by later authors into physical and divine. Physical fate is an order and series of natural causes, with their consequent effects; and the results of it are all the events and phenomena of nature. Divine fate is what is more usually called *Providence.*

FATESCH, one of the circles into which the Russian province of Kursk is divided. It is a district fertile in corn, watered by the Usoscha, and contains about 46,000 inhabitants. The chief place is of the same name, and has a population of 2450 persons. It is situated in long. 37. 5. E. and lat. 52. 20. N.

FATHEMITES, Fathimites, or Fatimites, the descendants of the prophet Mahommed by Fathema, or Fatima, his daughter.

FATHER, a term of relation denoting a person who has begotten a child. By the laws of Romulus, a father had an unlimited power over his children. Amongst the Lacedæmonians, as we learn from Aristotle's *Politics,* the father of three children was excused from the duty of mounting guard for the security of the city; and the father of four children was exempted from every public burden. The Poppæan law, amongst the Romans, granted many valuable privileges to the father of three children, one of which was, that he should be excused from civil offices, and that the mother should have liberty, in her father's lifetime, to make a will, and manage her estate without the authority of tutors.

Natural Father is he who has illegitimate children.

Adoptive Father is he who takes the children of some other person, and acknowledges them as his own.

Putative Father is he who is only the reputed or supposed father.

Father is also used in theology to signify the first person in the Trinity.

Father, in *Ecclesiastical History,* is applied to ancient authors who have preserved in their writings the traditions of the church. Thus, St Chrysostom, St Basil, and others, are called Greek Fathers; St Augustin and St Ambrose, Latin Fathers. No author who wrote later than the twelfth century is dignified with the title of Father.

Father is also a title of honour given to prelates and dignitaries of the church, to the superiors of convents, to congregations of ecclesiastics, and to persons venerable for their age or quality. Thus we say, the right reverend father in God, the father general of the Benedictines, the fathers of the council of Nice, the father of his country, and so in many other cases.

FATHOM, a lineal measure containing six feet, and used chiefly at sea for measuring the length of cables and cordage.

FATSISIO, a barren and almost inaccessible island, about eighty miles from the south coast of the isle of Niphon. Thither criminals are banished, and employed in making gold brocade. Long. 140. 10. E. Lat. 33. 40. N.

FATUARII, in *Antiquity,* were persons who, appearing inspired, foretold things to come. The word is formed from *Fatua,* wife of the god Faunus, who was supposed to inspire women with the knowledge of futurity, as Faunus himself did men. Fatua had her name from *fari,* used in the same sense as *vaticinari,* to prophesy.

FAUNA, a deity amongst the Romans, who was daughter of Picus, and originally called *Marica.* Her marriage with Faunus procured her the name of *Fauna,* and her knowledge of futurity that of *Fatua* and *Fatidica.* It is said that she never saw a man after her marriage with Faunus, and that her uncommon chastity occasioned her being ranked among the gods after death. According to some, she is the same as *Bona Mater.*

FAUNALIA, in *Antiquity,* Roman feasts celebrated in honour of the god Faunus, who was the same amongst the Romans as *Pan* amongst the Greeks.

The Faunalia were held on the day of the nones of December, or on the fifth day of that month. The principal sacrifice was a roebuck, or rather, according to Horace, a kid, attended with libations of wine and the burning of incense. It was properly a country festival, being performed in the fields and villages with peculiar joy and devotion. Struvius in his Roman kalendar marks the feast of Faunus on the day of the ides of February; and the Faunalia he places on the fifth of the ides of December, or the 9th of that month. He also shows, that there really were two Faunalia; the one in February, mentioned by Ovid (*Fast.* lib. iv. ver. 246), and the other on the 9th of December, mentioned by Horace in the eighteenth ode of his third book.

FAUNS (*Fauni*), among the ancients, were a species of demi-gods inhabiting the forests, called also Sylvans (*Sylvani*), and differing little from the Satyrs. They delighted more particularly in vineyards, and generally appear as attendants of Bacchus, in the representation of Bacchanalian feasts and processions. The Fauns were represented as half men, half goats, having the horns, ears, feet, and tail of a goat, a very flat nose, and the rest of the figure human. Though the Fauns were considered as demi-gods, yet they were supposed to die after a long life. Arnobius shows that their father or chief, Faunus himself, lived only a hundred and twenty years.

FAUSSIGNY, a province of the duchy of Savoy, in the kingdom of Sardinia, with the title of a barony. It extends over 748 square miles, and contains three cities and seventy-two towns and villages, with 54,520 inhabitants. It is one of those provinces the neutrality of which was fixed by the congress of Vienna.

FAUSTUS. See Fust.

FAVERSHAM. See Feversham.

FAVIGNANA, an island on the west coast of Sicily, in the Mediterranean, named collectively the Formiche. It is situated to the south of Levanso, is a very fertile spot, and contains 2500 inhabitants, who grow corn, oil, wine, and cotton.

FAVISSÆ, in *Antiquity,* were, according to Festus and Aulus Gellius, cisterns for containing water. But the *favissæ* in the capitol at Rome were subterranean cellars, where old statues, broken vessels, and other things used in the temple, were usually laid up. They were much the same with the *archives* and *treasury* of modern churches.

FAVONIUS, amongst the Romans, the wind which blew directly from the west.

FAVORINUS, an ancient orator and philosopher of Gaul, who flourished under the emperor Hadrian, and taught with high reputation both at Athens and Rome. Many works are attributed to him, amongst which may be mentioned a Greek miscellaneous history, often quoted by Diogenes Laertius.

FAWKES, Francis, a poet of some note, who received his school education at Leeds, whence he was removed to Jesus College, Cambridge, where he took the degrees in arts. Having early entered into holy orders, he settled first at Bramham in Yorkshire, near the elegant seat of that name, which he celebrated in verse in 1745, in a quarto pamphlet published anonymously. His first poetical publications were, Gawin Douglas's Description of May and Winter modernized. Having afterwards removed to the curacy of Croydon in Surrey, he recommended himself to the notice of Archbishop Herring, then residing there on account of his health, to whom, besides other pieces, he addressed an ode on his recovery in 1754, which is printed in Mr Dodsley's collection. In 1755 his grace collated him to the vicarage of Orpington, with St Mary Gray in Kent; and Mr Fawkes lamented his patron's death in 1757 in an elegy styled *Aurelius,* first printed, with his grace's seven sermons, in 1763. In April 1774, by the favour of Dr

Plumtree, he exchanged his vicarage for the rectory of Hayes. He was also one of the chaplains to the princess dowager of Wales. He published a volume of poems by subscription in 8vo, 1761; the Poetical Kalendar, 1763, and Poetical Magazine, 1764, in conjunction with Mr Woty; Partridge Shooting, an eclogue, to the honourable Charles Yorke, 1767, 4to; and a Family Bible with notes, in 4to, a compilation. But his great strength lay in translation, in which, since Pope, few have surpassed him. His fragments of Menander; his works of Anacreon, Sappho, Bion, Moschus, and Musæus, 12mo, 1760; his Idyllia of Theocritus, by subscription, 8vo, 1767; and his Argonautics of Apollonius Rhodius, by subscription, a posthumous publication, completed by the Reverend Mr Meen of Emanuel College, Cambridge, 8vo, 1780, may be referred to in proof of this observation. He died on the 26th August 1777.

FAWN, among sportsmen, a buck or doe of the first year, or the young one of the buck's breed in its first year.

FAYOUM, a province of Egypt. See the article EGYPT.

FE, SANTA, a city of Spain, on the river Xenil, in the province of Granada, which was almost entirely overthrown by an earthquake in 1807. Near to it is Sota de Roma, the estate conferred on the Duke of Wellington by the government of Spain.

FE, FO, or FOHI, the name of the chief god of the Chinese, whom they adore as the sovereign of heaven. They represent him as shining all in light, with his hands hid under his robes, to show that his power does all things invisibly. He has at his right hand the famous Confucius, and at his left Lanza or Lanca, chief of the second sect of their religion.

FEALTY, in *Law*, an oath taken on the admittance of any tenant, to be true to the lord of whom he holds his land. By this oath the tenant holds in the freest manner, on account that all who have fee hold *per fidem et fiduciam*, that is, by fealty at the least.

This fealty, at the first creation of it, bound the tenant to fidelity, the breach of which was the loss of his fee. It has been divided into general and special; general, that which is to be performed by every subject to his prince; and special, required only of such as, in respect of their fee, are bound by oath to their lords. To all manner of tenures, except tenancy at will, and frank-almoign, fealty is incident, though it chiefly belongs to copyhold estates held in fee and for life.

FEAR is defined an apprehension of impending evil, attended with a desire of avoiding it. Fear in the extreme is called *terror*. Fear, in Scripture, is used in various senses. The *fear of God* is either filial or servile. Filial fear is a holy affection or gracious habit in the soul, by which it is inclined to obey all God's commandments, and to hate and avoid evil. Slavish or servile fear is the consequence of guilt; a judicial impression produced by sad thoughts of the provoked majesty of heaven; an alarm within that disturbs the rest of a sinner. Though this fear be in wicked men, yet it is often preparative to faith and repentance. *Fear* is likewise used for the *object* of fear. God says that he will send his *fear* before his people; that is, a dread wrought by him, in order to terrify and destroy the inhabitants of Canaan.

FEAR was deified by the Pagans. Tullius Hostilius brought the worship of this deity to Rome. The Ephori of Sparta erected a temple to Fear, near their tribunal, in order to strike awe into those who approached it. Fear was likewise worshipped at Corinth.

FEAST, or FESTIVAL, in a religious sense, is the ceremony of feasting and thanksgiving. The word is formed from the Latin *festum*, which some derive *a feriari*, to keep holiday; others, however, derive it from the Greek ἑστιαω, *I feast* or *entertain*, from ἑστια, *hearth*, or *fire*. Feasts and the ceremonies connected with them have formed great part of the religion of almost all nations and sects; of the Greeks, Romans, Hebrews, Christians, and Mahommedans.

The first feasts amongst the Greeks were celebrated in solemn assemblies of the whole nation, on occasion of their games, as the Olympian, the Pythian, the Isthmian, and Nemæan; but in process of time they had many others, the principal of which are enumerated in the course of this work.

The Romans also had abundance of stated feasts in honour of their deities and heroes; as the Saturnalia, Cerealia, Lupercalia, Liberalia, Neptunalia, Consualia, Portumnalia, Vulcanalia, Palilia, Divalia, and others. They had also feasts instituted occasionally, as Carmentalia, Quirinalia, Terminalia, Floralia, Compitalia, Lemuria, Vernalia; besides other moveable and occasional ones, to give thanks to the gods for benefits received; to implore their assistance, or to appease their wrath, as the Paganalia, Feralia, Bacchanalia, Ambarvalia, Amburbalia, Suovetaurilia, and various others, denominated *feriæ;* as Sementinæ, Latinæ, &c. The feasts were divided into days of sacrifice, and days of banqueting and feasting; days of games, and days of rest or *feriæ*. As there was but little history written, or at least published, in those days, one end of these feasts was to preserve the remembrance of past occurrences.

The principal festivals of the Jews were the feast of trumpets, that of the expiation, that of tabernacles, that of the dedication, that of the passover, that of pentecost, and that of purification. The modern Jews have other feasts marked in their kalendar, but these are of modern institution. The Mahommedans, besides their weekly feast or Sabbath, which is observed on Friday, have two solemn feasts, the first of which is called the Feast of Victims, and celebrated on the tenth day of the last month of their year; and the second is called Bairam. The Chinese have two solemn annual feasts, in the memory of Confucius, besides others of less note on various days of the year.

Festivals amongst us are either *immoveable* or *moveable*. *Immoveable feasts* are those constantly celebrated on the same day of the year. The principal of these are Christmas day or the Nativity, the Circumcision, Epiphany, Candlemas or the Purification, Lady Day or the Annunciation, called also the Incarnation and Conception, All Saints, and All Souls; besides the days of the several apostles, which with us are feasts, though not *feriæ*. *Moveable feasts* are those which are not confined to the same day of the year. Of these, the principal is Easter, which gives the law to the rest, all of them following and keeping their proper distances from it; as Palm Sunday, Good Friday, Ash-Wednesday, Sexagesima, Ascension-Day, Pentecost, and Trinity-Sunday. The four feasts which the English laws take special notice of are, the Annunciation of the blessed Virgin Mary, or Lady Day, the 25th of March; the nativity of St John the Baptist, on the 24th of June; the Feast of St Michael the Archangel, on the 29th of September; and that of St Thomas the Apostle, on the 21st of December.

Besides these feasts, which are *general*, and enjoined by the church, there are others *local* and *occasional*, enjoined by the magistrate, or voluntarily observed by the people; as days of thanksgiving for delivery from wars, plagues, and other evils; and also the vigils or wakes in commemoration of the dedication of particular churches.

The prodigious increase of festival days in the Christian church commenced towards the close of the fourth century, and was occasioned by the discovery which was then made of the remains of martyrs and other holy men, for the commemoration of whom they were established. But instead of being set apart for pious exercises, these festivals were abused in indolence, voluptuousness, and criminal practices. Many of them were instituted on a Pâgan model, and perverted to the most scandalous purposes.

Feast is also used to signify a banquet or sumptuous entertainment, without any immediate view to religion.

The use of the word, in this sense, arises from the circumstance that part of the ceremony in many of the ancient festivals, both those of the heathens and of the Christians, was good eating; though Huet chooses to derive the word from *festinare*, which, in an ancient Latin version of Origen's Commentary on Matthew, signifies to feast: *Ut veniens illuc Jesus festinet, cum discipulis suis.*

Social or civil feasts were also expressed by the words *convivium* and *compotatio* or *concœnatio*. Cicero says that, in the Roman language, the word *convivium*, which means people assembled at table, is more significant of refinement than the Greek word *compotatio* or *concœnatio*. The Roman term, says he, expresses the conjunction of body and mind which ought to take place at an entertainment; the Greek merely denotes what relates to the body alone.

As food is necessary to our existence, eating together forms a bond of association among mankind. People at a feast, says one of the ancients, seem to form but one body and one soul. All nations, whether savage or civilized, have regarded the pleasures of the table as the occasion of the most agreeable society. This species of enjoyment, abstracting from its susceptibility of abuse, makes but one family of all whom it brings together. It levels the distinctions introduced by policy or prejudice, and disposes men to regard one another as brethren. It is here that people feel the equality established by nature, forget the evils of life, extinguish their hatred, and cause their enmities to cease. For this reason Aristotle considers as a breach of the social principle the custom of eating apart which obtained amongst the ancient Egyptians, and praises the convivial repasts established by Minos and Lycurgus.

The Persians generally deliberated on business at table, but never determined or put their determinations in execution, except in the morning before having eaten.

When the Germans, says Tacitus, wanted to reconcile enemies, to form alliances, to appoint chiefs, or to treat of war and peace, it was during the repast that they took counsel; a time in which the mind is most open to the impressions of simple truth, or most easily animated to great attempts. These artless people during the conviviality of the feast spoke without disguise, and next day weighed the counsels of the former evening; they deliberated at a time when they were not disposed to deceive, and took their resolution when they were least liable to be deceived.

By a fundamental law of the state, people of rank amongst the Rhodians were obliged to dine daily with those who had the management of affairs, in order to deliberate with them concerning such things as were necessary or useful for the country; and on this account the principal ministers of the kingdom were obliged to keep open table for all who could be of service to the state.

Amongst the Romans, the place where they supped was generally the vestibule, lest a more retired part of the house should encourage licentiousness and disorder. There were several laws which restricted their meals to the vestibules. But when luxury reigned at Rome, the wealthy had superb halls for their entertainments. Lucullus had many, each of which bore the name of some deity; and this was a mark which indicated to the servants the expense of the entertainment. The expense of a supper in Lucullus's hall of Apollo amounted to fifty thousand drachmas. The hall in which Nero feasted imitated the revolutions of the heavens, by the circular motion of its walls and its ceiling; and represented the different seasons of the year, changing at every course, and showering down flowers and perfumes on the guests.

The Romans did not, like us, confine themselves to one table at their feasts; they had generally two; one for the service of animal food, which was afterwards removed; and another for the dessert, at which last they sung, and poured out their libations. The Greeks and eastern nations observed the same custom, and even the Jews in their solemn feasts and at sacrifices.

The Romans, in the time of Nero, had tables made of citron wood brought from Mauritania, which were covered with purple and gold, and raised on feet of carved ivory. It is said that these tables were more precious than gold itself. Dion Cassius affirms that Seneca had five hundred of these, which he made use of one after another; and Tertullian informs us that Cicero had only one. The Romans usually chose the king of the feast, or chairman as we would call him, by a cast of the dice.

We learn from Herodotus that the ancients had neither cups nor bowls, but drank out of little horns tipped with silver or gold.

The Greeks and Romans kept a domestic for the purpose of reading during their meals and feasts. The head of the family sometimes performed the office of reader himself; and we learn that the Emperor Severus often read whilst his family sat or rather reclined at table. The time of reading was generally at supper; and guests were invited to a reading, as they are now a-days to play cards. In their flourishing times the Greeks did not, according to their own expression, profane the sanctity of the table, but rather adorned it with ingenious and elegant conversation, proposing moral topics, of which Plutarch has preserved a collection. Ancient philosophers have remarked, that heroes rarely assembled convivially without bringing affairs of consequence into discussion, or deliberating upon those which regarded either present affairs or future contingencies.

When Rome became corrupted with luxury, singers, dancers, musicians, stage-players, and people who told pleasant tales, were brought into the hall to amuse the guests. Plutarch informs us that Cæsar, after his triumphs, treated the Roman people at twenty-two thousand tables; and by calculation it would seem that there must have been at these tables upwards of two hundred thousand persons.

It was a custom among the Romans, at the end of a feast, to drink out of a large cup as often as there were letters in the names of their mistresses.

Feasting seems to have been the chief delight of the Germans, Gauls, Britons, and all the other Celtic nations; and in this they indulged themselves to the utmost, as often as they had an opportunity. "Amongst these nations," says an author who had carefully studied their manners, "there is no public assembly, either for civil or religious purposes, duly held; no birth-day, marriage, or funeral, properly celebrated; no treaty of peace or alliance rightly cemented, without a great feast." It was by frequent entertainments of this kind that the great men or chieftains gained the affections and rewarded the services of their followers; and those who made the greatest feasts were sure to be most popular, and to have the largest retinue. These feasts, in which plenty was more regarded than elegance, commonly lasted several days, and the guests seldom retired until they had consumed the provisions and exhausted the liquors provided for the occasion. Athenæus describes an entertainment given by Arcamnes, a wealthy prince of Gaul, which continued a whole year without interruption, and at which all the people of Gaul, and even all strangers who passed through that country, were made welcome. At these feasts they sometimes consulted about the most important affairs of state, and formed resolutions relating to peace and war; imagining that men spoke their real sentiments with the greatest freedom, and were apt to form the boldest designs, Feather ‖ Fechingse.

when their spirits were exhilarated with the pleasures of the table. The conversation at these entertainments frequently turned on the great exploits which the guests themselves or their ancestors had performed in war; a circumstance which sometimes occasioned quarrels, and even bloodshed.

As to the drink used at these feasts, particularly in Britain, it seems probable that before the introduction of agriculture into the island, mead, or honey diluted with water, was the only strong liquor known to its inhabitants, as it was to many other ancient nations. And this continued to be a favourite beverage amongst the ancient Britons and their posterity long after they had become acquainted with other liquors. The mead-maker was the eleventh person in dignity in the courts of the ancient princes of Wales, and took place next to the physician. An ancient law of that principality shows how much this liquor was esteemed by the British princes. "There are three things in the court which must be communicated to the king before they are made known to any other person: first, every sentence of the judge; second, every new song; and, third, every cask of mead." This was perhaps the liquor which is called by Ossian the joy and strength of shells, with which his heroes were so much delighted. After the introduction of agriculture, ale or beer became the most general drink of all the British nations who practised that art, as it had long been of all the Celtic nations on the Continent. If the Phœnicians or Greeks imported any wine into Britain, it was only in small quantities; and that generous liquor was but little known in this island until after it had been conquered by the Romans.

In the reign of Charles V. of France, the custom of placing the lights upon the table had not yet been introduced. A number of domestics held the lights in their hands during the whole time of the repast.

FEATHER, in *Physiology*, a general name for the covering of birds; it being common to the animals of this class to have their whole body, or at least the greater part of it, covered with feathers or plumage. Feathers form a considerable article in commerce, particularly those of the ostrich, heron, swan, peacock, and goose, for plumes, ornaments of the head, filling of beds, writing-pens, and the like.

Geese are plucked five times a year in some parts of Great Britain; and in cold seasons many of them die by this barbarous custom. Those feathers which are brought from Somersetshire are esteemed the best, and those from Ireland the worst.

Eider down is imported from Denmark; the ducks which supply it being inhabitants of Hudson's Bay, Greenland, Iceland, and Norway. Our own islands west of Scotland breed numbers of these birds, which form a profitable branch of trade to the poorer class of the inhabitants. Hudson's Bay also furnishes very fine feathers, supposed to be of the goose kind. The down of the swan is brought from Dantzic.

FEBRIFUGE, an appellation given to such medicines as serve to mitigate or remove a fever.

FEBRUARY, in *Chronology*, the second month of Numa's year. This month is not found in the calendar of Romulus, but was added to the year by Numa. It had its name from *Februa*, *Februaca*, or *Februalis*, all names of Juno, who presided over the purifications of women; in this month also the Lupercalia were held in honour of Juno, and women were purified by the priests of Pan Lyceus at that festival. February, in a common year, consists only of twenty-eight days; but in bissextile year it has twenty-nine, on account of the intercalary day added that year.

FECHINGSE, a small and neatly-built city of China, in the province of Pe-tche-li, near Pekin. It has a good appearance, though the houses are low, from the walls and pavilions being kept in good repair. Near the town is a fine bridge crossing the river; it is built of stone, and is 216 paces in length.

F mp ‖ e.

FECAMP, a sea-port city of the department of the Lower Seine, in France, situated at the mouth of the river of the same name. It has a good tide harbour. It contains 1000 houses and 7939 inhabitants, many of whom are employed in the herring and mackerel fisheries, some in ship-building, and others in the manufacture of sail-cloth, flannels, counterpanes, and tent-cloth. Long. 0. 16. 40. E. Lat. 49. 46. N.

FECIALES, or Fœciales, an order of priests or officers amongst the ancient Romans, consisting of twenty persons, appointed to proclaim war, to negotiate peace, and to perform various other duties.

Festus derives the word from *ferio*, I strike, as *ferire fœdus* signifies to conclude a treaty; and accordingly, instead of *feciales* he would have it written *feriales*. Others derive it from *fœdus*, which was anciently written *fedus*, probably from *fides*, faith; and others again from *facio*, *feci*, I make, because they made war and peace. Vossius chooses to derive it from *fatu*, the latter supine of the verb *fari*, to speak, in which sense the *feciales* should be the same with *oratores;* and this opinion is also confirmed by the authority of Varro, who says that they were called indifferently *feciales* and *oratores*.

The *feciales* were a sort of heralds, who, when the Romans had any dispute with their neighbours, were sent first to demand the thing intended to be usurped, or to require satisfaction for the injury alleged to be done. If an answer satisfactory to the people and the senate was not returned by them, they were dispatched again to declare war; and the same thing took place in treating for peace, the *feciales* being the only persons appointed to negotiate between the senate and the enemy.

Plutarch, in the life of Numa, and Dionysius of Halicarnassus, observe that the *feciales* were first instituted by that prince. The latter adds that they were originally chosen out of the best families in Rome; that their office, which was reputed a sort of *sacerdotium*, or priesthood, only ended with their life; that their persons were sacred and inviolable, like those of other priests; that they were even charged to see that the republic did not declare war unjustly; that they were authorized to receive the complaints and remonstrances of nations who pretended to have been in any way injured by the Romans; that if these complaints were found just, they were bound to seize the criminals, and to deliver them up to those whom they had offended; that they were invested with the rights and privileges of ambassadors; that they not only concluded treaties of peace and alliance, but took care that these were executed, and even abolished them, if they were found not to be equitable. Livy (lib. i. cap. 24) ascribes the institution of *feciales* to Ancus Martius, in the year of Rome 114. But Varro assures us, that in his time most of the functions of the *feciales* were set aside; though Plutarch observes that they had still some authority in his time.

The *feciales* were crowned with *verbena* or vervain when they proceeded to declare war. The head was covered with a veil, over which the crown was applied. In this equipage they proceeded to the frontiers of the country which had been declared hostile, and threw a bloody dart or javelin into the ground within the same. In Livy and other ancient authors we have the formula used in such declarations.

FEE, in *Law*, signifies a complete feudal property. See Feudal Law.

Fee also signifies a certain allowance or *honorarium* to barristers, physicians, and certain other professional persons, as a reward for their pains and labour.

Fee-Farm, a kind of tenure without homage, fealty, or other service, except that mentioned in the feoffment, which is usually the full rent, or at least a fourth part of it.

FEEJEE Islands, a group of islands in the South Pacific Ocean, the exact number of which has not been ascertained. They are situated from about 15. 33. to 19. 15. of south latitude, and extend to about 175. east longitude. They are equally fertile with the generality of the islands in the South Pacific Ocean, and abound in the same sort of produce. Sandal wood is plentiful, and a considerable trade is carried on with the Europeans in this article. The inhabitants are a ferocious race, being all cannibals. These islands were originally discovered by Tasman in the year 1643. They were seen by Captain Bligh in the years 1789 and 1792; and many European vessels have since visited them.

FEET-Bearer, the name of an officer in the courts of the ancient Anglo-Saxon and Welsh princes. He was a young gentleman, whose duty it was to sit on the floor, with his back towards the fire, and hold the king's feet in his bosom all the time he sat at table, in order to keep them warm and comfortable; a piece of state and luxury unknown, and, we may add, unnecessary, in modern times.

FEHRABAD, or **Fahrabad**, a town of Persia, in the province of Mazanderan, situated on the southern shore of the Caspian Sea, at the mouth of a river. Its population, formerly computed at 16,000, consisted principally of Armenians and Georgians, who are represented as having been lively, active, and industrious. The neighbouring country is fertile, producing sugar, cotton, and silk; and the inhabitants carry on a trade in rice, salt-fish, and pottery. It is 126 miles west of Asterabad, and 270 north of Ispahan. Long. 53. 12. E. Lat. 35. 56. N.

FELANICHE, a Spanish town on the island and in the province of Majorca, with some distilleries of brandy and wine, and with a population of 6800 souls. Long. 0. 14. W. Lat. 39. 32. N.

FELAPTON, in *Logic*, one of the six first modes of the third figure of syllogisms; the first proposition being an universal negative, the second an universal affirmative, and the third a particular negative.

FELEGYAZA, a city of Hungary, in the circle of the Hither Danube, where the archives of the circle are preserved, and all the legal processes are carried on. It is also the head quarters of the army. It contains 1028 houses and 9405 inhabitants. Long. 19. 45. E. Lat. 46. 43. N.

FELIBIEN, Andre', was born at Chartres in 1619, and went as secretary under the Marquis de Fontenay-Mareuil, who was French ambassador at the court of Rome in 1647. On his return M. Colbert procured him the place of historiographer to the king, and also that of superintendent of buildings, and of the arts and manufactures, in France. He became afterwards deputy comptroller-general of the bridges and dykes in that kingdom; and died in 1695. Felibien wrote several pieces relating to the fine arts, the principal of which is his Dialogues on the Lives and Works of the most eminent Painters.

FELICITAS, Felicity, or *Happiness*, was deified by the ancient Pagans. Lucullus built a temple to this goddess, and Lepidus erected another. The Greeks paid divine worship to Macaria, daughter of Hercules, who was the same with the Felicitas of the Romans. This deity is pictured upon medals, generally with a cornucopia in one hand, and a caduceus in the other.

FELICUDI, one of the Lipari Islands, in the Mediterranean Sea, belonging to the kingdom of Naples. It is inhabited by about 1200 persons, who grow wheat and produce wine, some of which is shipped at the small haven.

FELO de Se, in *Law*, a person who deliberately lays violent hands on himself, and is the occasion of his untimely death, whether by hanging, drowning, stabbing, shooting, or in any other way.

FELON, in *Law*, a person guilty of felony.

FELONY, in the general acceptation of the law, comprehends every species of crime which occasions at common law the forfeiture of lands or goods. This most frequently happens in those crimes for which a capital punishment either is or used to be inflicted; for those felonies which are called *clergyable*, or to which the benefit of clergy extends, were anciently punished with death in all lay or unlearned offenders; though now, by the statute law, that punishment is for the first offence universally remitted. Treason itself, says Sir Edward Coke, was anciently included under the name of *felony*; and in confirmation of this we may observe, that the statute of treasons (25 Edw. III. c. 2), speaking of some dubious crimes, directs a reference to parliament, that it may be there adjudged "whether they be treason or *other* felony." All treasons, therefore, strictly speaking, are felonies; though all felonies are not treason. And to this also we may add, that all offences now capital are in some degree or other felonies; but this is likewise the case with some other offences which are not punished with death, as suicide, where the party is already dead, homicide by chance-medley or in self-defence, and petit-larceny or pilfering; all which are, strictly speaking, felonies, as they subject those who commit them to forfeitures. Upon the whole, therefore, the only adequate definition of felony seems to be that which was before laid down, namely, an offence which occasions a total forfeiture of either lands or goods, or both, at the common law, and to which capital or other punishment may be superadded, according to the degree of guilt.

The word *felony*, or *felonia*, is undoubtedly of feudal original, being frequently to be met with in the books of feuds, and in other works; but the derivation of it has much puzzled the juridical lexicographers Pratæus, Calvinus, and others. Some derive it from the Greek φηλος, *an impostor* or *deceiver*; others from the Latin *fallo, fefelli*, to countenance which they would have it called *fellonia*. Sir Edward Coke, as his manner is, has given us a still stranger etymology; that it is *crimen animo felleo perpetratum*, a crime perpetrated with a bitter or gallish inclination. But all agree in the description that it is such a crime as works a forfeiture of the offender's lands or goods. And this gives great probability to Sir Henry Spelman's derivation from the Teutonic or German, in which language, indeed, as the word is clearly of feudal origin, we ought rather to look for its signification, than amongst the Greeks and Romans. *Felon*, then, according to him, is derived from two northern words, namely, fee, signifying the fief, feud, or beneficiary estate; and lon, which means price or value. Felony is therefore the same as *pretium feudi*, the consideration for which a man gives up his fief; as we say in common speech, such an act is as much as your life or estate is worth. In this sense it clearly signifies the feudal forfeiture or act by which an estate is forfeited, or escheats to the lord.

To confirm this we may observe, that in the sense of forfeiture to the lord, the feudal writers constantly use it. For all those acts, whether of a criminal nature or not, which at this day are generally forfeitures of copyhold estates, are styled *feloniæ* in the feodal law: *scilicet, per quas feudum amittitur*. Thus, *si domino deservire noluerit; si per annum et diem cessaverit in petenda investitura; si dominum ejuravit*, id est, *negavit se a domino feudum habere; si a domino in jus eum vacante, ter citatus non comparuerit*; all which, with many others, are still causes of forfeiture in our copyhold estates, and were denominated *felonies* by the feudal constitutions. So likewise injuries of a more substantial or criminal nature were denominated *felonies*, that is, forfeitures; as assaulting or beating the lord; vitiating his wife or daughter, *si dominum cucurbitaverit*, id est, *cum uxore ejus concubuerit*; all these are esteemed felonies, and the latter is expressly so denominated, *si fecerit feloniam, dominum forte cucurbitando.* And as these contempts or smaller offences were felonies or acts of forfeiture, of course greater crimes, as murder and robbery, fell under the same denomination. On the other hand, the lord might be guilty of felony, or forfeit his seignory to the vassal, by the same act as that by which the vassal would have forfeited his feud to the lord. *Si dominus commisit feloniam, per quam vasallus amitteret feudum si eum commiserit in dominum, feudi proprietatem etiam dominus perdere debet.* One instance given of this sort of felony in the lord is beating the servant of his vassal, so that his service is lost; which seems merely in the nature of a civil injury, in as far as it respects the vassal. And all these felonies were to be determined *per laudamentum sive judicium parium suorum*, in the lord's court; as with us forfeitures of copyhold lands are presentable by the homage in the court-baron.

Felony, and the act of forfeiture to the lord, being thus synonymous terms in the feudal law, we may easily trace the reason why, upon the introduction of that law into England, the crimes which induced such forfeiture or escheat of lands (and, by a small deflection from the original sense, such as induced the forfeiture of goods also) were denominated *felonies*. Thus it was that suicide, robbery, and rape, were felonies; that is, the consequence of such crimes was forfeiture: but by long use we began to signify by the term of *felony* the crime actually committed, and not the penal consequence thereof. And upon this system only can we explain the reason why treason in ancient times was held to be a species of felony; we mean, because it induced a forfeiture.

Hence it follows, that equal punishment does not by any means enter into the true idea and definition of *felony*. Felony may be without inflicting capital punishment, as in the cases instanced of self-murder, excusable homicide, and petit-larceny; and it is possible that capital punishments may be inflicted, and yet the offence be no felony, as in the case of heresy by the common law, which, though capital, never worked any forfeiture of lands or goods, an inseparable incident to felony. And of the same nature was the punishment of standing mute, without pleading to an indictment; which at the common law was capital, but without any forfeiture, so that such standing mute was no felony. In short, the true criterion of felony is forfeiture; for, as Sir Edward Coke observes, in all felonies which are punishable with death, the offender loses his lands in fee-simple, and also his goods and chattels; but in such as are not punishable he loses his goods and chattels only.

The idea of felony is indeed so generally connected with that of capital punishment, that we find it hard to separate them; and to this usage the interpretations of the law now conform. If a statute, therefore, makes any new offence felony, the law implies that it shall be punished with death, that is, by hanging as well as forfeiture, unless the offender pray the benefit of clergy; which all felons are entitled once to have, unless the same is expressly taken away by statute.

FELT, in *Commerce*, a sort of stuff deriving all its consistence merely from being fulled, or wrought with lees and size, without either spinning or weaving. Felt is made either of wool alone, or of wool and hair.

FELTING, the method of working up hair or wool into a species of cloth, independently of either spinning or weaving. Felting in Britain is not much practised, excepting in the manufacturing of hats. See HAT-MAKING.

FELUCCA, in nautical affairs, a little vessel rowed with six oars, and frequent in the Mediterranean. It has this peculiarity, that its helm may be applied either in the head or stern, as occasion requires.

FELUDJE, FELUGIA, a village of Asiatic Turkey, situated on the eastern shore of the Euphrates, north of Hillah, in a fertile soil, productive in dates, grapes, grain, and cotton. Here a palace was erected by Soliman the Great, pasha of Bagdad. It was anciently a place of celebrity, and taken by the Romans under the Emperor Julian.

FELUDSJE, FELUJA, a small island in the north-west part of the Gulf of Persia, near the Arabian shore. It is ten miles east of Koueit. Long. 48. E. Lat. 29. 45. N.

FEMALE (FŒMINA), a term peculiar to animals, signifying that sex which conceives and generates its young.

FEMERN, an island in the Baltic Sea, a part of the kingdom of Denmark, the centre of which is in latitude 54. 29. north, and longitude 10. 24. east. The extent of it is fifty-two square miles, or 33,280 acres. It contains a city and market-town, and forty villages, with 7626 inhabitants. The soil is productive, and the sea around it abounds with fish, the taking of which affords occupation to many of the inhabitants. The capital is Burg.

FEMME COVERT, in *Law*, signifies a married woman.

FEMME Sole, an unmarried woman, whose debts, contracted before marriage, become those of her husband after it.

FEMININE, in *Grammar*, one of the genders of nouns, namely, the second.

The feminine gender is that which denotes that the noun or name belongs to a female. In the Latin the feminine gender is formed from the masculine by altering its termination, particularly by changing *us* into *a*. Thus, of the masculine *bonus equus*, a good horse, is formed the feminine *bona equa*, a good mare; and so, of *parvus homo*, a little man, is formed *parva fœmina*, a little woman.

In French, the feminine gender is expressed, not by a different termination, but by a different article. Thus, *le* is joined to a male, and *la* to a female.

In English, we are generally more strict, and express the difference of sex, not by different terminations nor by different particles, but by different words; as boar and sow, boy and girl, brother and sister; though sometimes the feminine is formed by varying the termination of the masculine into *ess*, as in abbot, abbess, and the like.

FEN, a place overflowed with water, or abounding with bogs. Fens are either made up of a congeries of bogs, or consist of a multitude of pools or lakes, with dry spots of land intermixed, like as many little islands.

FENCE, in *Gardening* and *Husbandry*, a hedge, wall, ditch, bank, or other inclosure, made round gardens, fields, woods, and the like.

FENCE-Month, the month in which deer begin to fawn, and during which it is unlawful to hunt in the forest. It commences fifteen days before midsummer, and ends fifteen days after it. This month, by ancient foresters, is called *defence-month*.

FENCING, is the proper use of the small-sword or foil. The small-sword is a light court-dress sword, made to taper gradually from the hilt to the point, and of a size regulated by the judgment of the wearer, if he understand the use of the weapon. The foil, with which the art of fencing is practised, is a small quadrangular blade, about the length of a small sword, and mounted in nearly the same manner; but, for the convenience of the exercise, it is made lighter, blunted, and covered with leather at the point, to prevent accidents in practice.

The first weapon in use amongst mankind, whether for offensive or defensive purposes, appears to have been the sword, and combat with this weapon is perhaps nearly as old as the world. The most ancient book extant makes frequent mention of the sword, and the same thing may be said of Homer, who is full of continual allusions to this weapon. The earliest swords were probably made of wood, like those used by the natives of Mexico when first visited by the Spaniards; but after the discovery of metals, copper swords were introduced, of which kind many have at different times been found in Ireland. As soon, however, as the art of tempering steel had been discovered, that metal superseded all other substances in the fabrication of arms; nor is it probable that any change in this respect will take place, or that any further improvement is attainable. The form of the sword, however, has varied at different times and in different countries. Those used by the Roman legions were short and strong, with a blade seldom exceeding nineteen inches in length, but two-edged, and calculated both for the cut and the thrust. The British swords, called *spathæ*, were large, long, and heavy; and the Saxon and the Norman partook of the same character. The ancient practice of the weapon was probably carried to its greatest perfection amongst the Romans, whose partiality for gladiatorial exhibitions formed a remarkable feature of their character. The various and complicated methods of combat in which this celebrated people took delight are either alluded to or described by most of their writers, particularly by Livy, Juvenal, Seneca, and Suetonius.

The history of the modern small-sword or rapier is involved in some obscurity. The latter term, though now considered as synonymous with the former, properly denotes a long, ordinary, old-fashioned, cutting sword. But modern usage has identified the expressions, and by a rapier is now always meant a sword for the thrust, in contradistinction to one constructed for cutting. The small-sword or rapier is undoubtedly very ancient, although there is reason to believe that it was not brought into general use until armour began to wear out of fashion. Since that time the art of fencing has always been considered as a gentlemanly accomplishment, and in many parts of the Continent it is cultivated with the greatest zeal and assiduity. Shakspeare, indeed, makes Hamlet, who lived at the court of Florwendillus, a fencer; but as our great dramatist has not been very careful in avoiding anachronisms, it may reasonably be doubted whether the small-sword has any claim to such antiquity. Some have maintained that the weapon was not used in England before the reign of Elizabeth; and Darcie (*Annals of Elizabeth*) informs us that one Rowland York, who appears to have betrayed Deventer to the Spaniards in the year 1587, was the first who brought into England "that wicked, pernicious fashion to fight in the fields in duels with a rapier called a tucke only for the thrust." Stowe also mentions that long tucks and long rapiers began about the twelfth or thirteenth year of Elizabeth, and that "he was held the greatest gallant that had the deepest ruffe and largest rapier. The offence," he adds, "to the eye of the one, and the hurt unto the life of the subject that came by the other, caused her majesty to make proclamation against them both, and to place selected grave citizens at every gate to cut the ruffes and breake the rapier's points of all passengers that exceeded a yard in length of their rapiers, and a nayle of a yard in depth of their ruffes."[1]

But at what time soever the small-sword came into use in this country, it is not surprising that, when once introduced, it should have been cultivated as the fairest and most equitable instrument of duelling. Before this period meetings for the purpose of single combat were utterly revolting to human nature. No regard was paid to equality of arms or numbers; advantages, however unfair, were seized whenever an opportunity offered; and the ferocious passions, instead of being curbed, had fuller scope given for their gratification. "The duellist of former times," says Sir Walter Scott, in a note to *The Lady of the Lake*, "did not always stand upon those punctilios respecting equality of arms, which are now judged essential to fair combat. It is true that in formal combats in the lists, parties were, by the judges of the field, put as nearly as possible in the same circumstances. But in private duels it was often otherwise." In the desperate combat which was fought between Quelus, a minion of Henry III. of France, and Antraquet, with two seconds on each side, and from which only two persons escaped alive, Quelus complained that his antagonist had the advantage of a poniard which he used in parrying, whilst his own left hand, which he was obliged to use for the same purpose, had been cruelly mangled. When he charged Antraquet with this odds, "Thou hast done wrong," answered the latter, "to forget thy dagger at home; we are here to fight, not to settle punctilios of arms." In another duel of a similar kind, however, a younger brother of the house of Aubange in Angoulême behaved more generously, and at once threw away his dagger when his antagonist challenged it as an undue advantage. Nevertheless, it would be difficult to conceive any thing more brutal and savage than the mode in which private quarrels were at this time conducted in France. Those who were most jealous on the point of honour, and who thence acquired the title of *raffinés*, did not scruple to avail themselves of every advantage of strength, numbers, surprise, and arms, in order to accomplish their revenge.

Brantôme, in his discourse on duels, informs us that the Italian masters of the science of defence made a great mystery of their art and mode of instruction; that they never suffered any person to be present except the scholar who was to be taught, and even examined beds, closets, and other places of probable concealment. The lessons of these teachers often gave the most treacherous advantages to their pupils; for the challenger having by usage a right to choose his weapons, frequently selected some strange and inconvenient kind of arms, the use of which he had practised under his instructor, and thus killed at his ease an antagonist, to whom, perchance, the weapon was presented for the first time on the field of battle. Nor can we doubt that the same, or even still more treacherous advantages, are taught by some Italian masters of the present day, especially when we learn, from an authentic publication of the life of a late pope, that in Rome upwards of a thousand persons annually fall victims to the stiletto, either by the hands of hired assassins, or in private quarrels. Dr Moore estimates the number of murders perpetrated by the dagger in Naples alone at not less than four hundred annually. Such are the cowardly and ferocious modes in which vengeance usually seeks its gratification amidst an enslaved and degraded people.

The practice of deciding duels with the sword, however, may be considered as now extinct in this country. When the rapier was looked upon as an indispensable part of a gentleman's dress, the facility of immediate rencounter which it offered gave occasion to frequent and dangerous brawls, by which the public tranquillity was disturbed, and the lives of peaceable citizens sometimes sacrificed. But still it may reasonably be doubted, whether the comparatively rare occurrence of duels since the introduction of the pistol, be not fearfully overbalanced by a long list of fatal results, not to mention amputated limbs and distressing mutilations. Be this as it may, however, the discontinuance of sword duels in England has, in a great measure, removed one of the chief objections against fencing; namely, that adroitness in the use of weapons creates a fondness for contention, and a disposition to indulge in violence and insult. Since arms have ceased to be worn, such an objection can no longer be urged against the art of defence; and it may perhaps be questioned whether it had much weight, even when arms formed part of the equipment of every one who called himself a gentleman. All parties were thus placed upon nearly an equal footing; and if turbulent characters went about armed, there was nothing to prevent the peaceably disposed from being as well provided as the brawlers, and also on a par with them in respect of skill in the use of weapons. If the thief makes use of a crowbar, the honest housekeeper has the protection of an iron bolt. The primary intention of fencing is the security of one's own person; and where the weapons and the art of using them skilfully were equally accessible to all, the evil disposed had no advantage, and therefore small temptation to indulge their turbulent propensities.

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[1] In *The Two Angry Women of Abingdon*, a comedy printed in 1599, we find the following pathetic complaint: "Sword and buckler fights begin to grow out of use. I am sorry for it; I shall never see good manhood again. If it be once gone, this poking fight of rapier and dagger will come up; then a tall man, and a good sword-and-buckler man, will be spitted like a cat or a rabbit."

The practice of the foil in England, however, is now confined to the most laudable purposes, namely, the enjoyment of salutary recreation, and the acquisition of a graceful and unconstrained deportment. The beneficial effects of moderate fencing to persons of weak constitutions, or of studious and sedentary habits, have been attested by medical practitioners of the first eminence. On this subject the suffrages of the most distinguished members of the British schools of medicine and of surgery, which Mr Angelo has annexed to his engravings, illustrative of the fencing attitudes, seem completely decisive.[1] To the public speaker, also, the practice of the fencing-room has been found to impart an ease and freedom of gesture attainable perhaps by no other exercise, not excepting even the discipline of the ballet-master. A modern writer on the subject of delivery or elocution, gives it as his opinion that the use of the foil and the broadsword diffuses ease, elegance, and grace all over the body, and imparts to the look and gesture an appearance of intellectual vigour. It does more; it teaches invaluable lessons of patience and self-command, and contributes to discipline the temper, whilst it serves to develope the corporeal powers, and to strengthen them by unconstrained and salutary exercise. We may add here, that several works of merit have appeared on this subject; but the most valuable and complete one yet published is Roland's *Treatise on the Theory and Practice of the Art of Fencing*, Edinburgh, 1823; nearly all the others we have met with being deficient either in explanation or in practical utility.

Having already described the weapons used in fencing, we shall now proceed to give such definitions as appear to be requisite for conveying a general idea of the subject, referring the reader for the necessary details to the excellent work of Mr Roland, which will be found equally clear in its explanations, and comprehensive in its views of every branch of the art.

After the first positions have been acquired, the different modes of attack come to be considered. *Attacks* are made in three ways: first, by a quick thrust proceeding merely from the wrist, the arm at the same time being elevated and advanced, with the point directed towards the adversary's breast; secondly, by what is technically called an extension; and, lastly, by longeing and recovering. The *parades*, in which consists the defensive part of the art, naturally follow the attack. A parade is a defence of the body, made by an opposition of one's blade to that of an adversary, in such a situation as, upon his attack, to prevent the point of his sword hitting. The parades are eight in number, viz. six simple, and two round or counter parades, and they are called *quarte, tierce, circle, octave, prime, quinte*, and round or counter in quarte and tierce. When and how these parades are made in fencing may be learned by consulting Mr Roland's work (p. 32 et seqq.).

The next division of the subject includes *straight thrusts, simple disengagements*, and *bindings of the blade*. A *straight thrust* is used as an attack, when an antagonist, from his position on guard, leaves sufficient opening to enable him to be touched upon that side of the body on which blades are joined. When such an opportunity offers, the wrist must be suddenly raised, so as to bring the *forte* of one's sword to the *foible* of the adversary's; after which *longe* immediately on the same line to his breast, observing, however, to preserve a correct opposition. In fencing, *opposition* signifies the art of covering the body at the time of delivering a thrust, on that side where the foils happen to cross, in order to prevent an antagonist exchanging hits. The *disengagement* is made either as an attack, or as a return after defending one's-self from a thrust, and is executed both under and over the wrist or foils. A disengagement over the arm may be parried with tierce or prime, and, if made low, by the parade of circle; from the position of octave, by quarte, or, if the thrust be delivered low, by circle; from the position of quinte, by prime as the readiest defence, but quarte and tierce are also correct parades against this thrust. There are three different ways of *binding the blade*. Of these, *flanconnade* is the principal, as it is sometimes a safe attack when any other mode would be attended with considerable danger; it is also made as a *riposte*. The attack of flanconnade is commenced when the blades are joined in quarte, and it is parried either by octave or quinte, or by the parade of quarte. The return over the arm, after the parade of circle, is parried by prime or tierce, or by changing quickly to the counter in quarte. The return over the arm, after the parade of prime, is parried by prime or tierce, or, if made at a considerable distance, by the counter in quarte.

In fencing there are a great variety of *feints*, which it is not easy to describe intelligibly without figures. A *feint* is an intentional movement made to deceive an adversary. All thrusts, therefore, may, strictly speaking, come under the definition of feints, as the fencer's object, in all his attacks, is to deceive his antagonist. For the sake of convenience, however, straight thrusts and simple disengagements have been arranged under a separate head. In executing the feint called *one, two*, inside of the arm, supposing the adversary's body to be covered in quarte, the parade of tierce is deceived; commencing from the outside, that of quarte is deceived; from the position of the circle the octave, and from that of the octave the circle is deceived.

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[1] "Perhaps there is no exercise whatever," says Mr Roland, "more calculated for these purposes (developing and cultivating bodily strength and activity) than fencing. Riding, walking, sparring, wrestling, running, and pitching the bar, are all of them certainly highly beneficial; but, beyond all question, there is no single exercise which combines so many advantages as fencing. By it the muscles of every part of the body are brought into play; it expands the chest, and occasions an equal distribution of the blood, and other circulating fluids, through the whole system. More than one case has fallen under the author's own observation, in which affections of the lungs, and a tendency to consumption, have been entirely removed by occasional practice with the foil; and he can state, upon very high medical authority, that since the institution of a *Salle d'Armes* at Geneva, scrofula, which was long lamentably prevalent there, has been gradually disappearing." (*Theory and Practice of Fencing*, p. 163.)

This feint, if made inside the arm, is parried by the parade of quarte, or by the counter in tierce, made upon an opponent's second disengagement; upon the outside of the arm, by tierce, prime, or the counter in quarte; and from the position of the octave, by octave or quinte. The feint *one, two*, is likewise made as a return after the parade of quarte or tierce, or sometimes after that of circle or octave. The *cut and disengage* is a species of *one, two*, in making which from the position of quarte, an adversary's parade of tierce is deceived, and from the position of tierce his parade of quarte. *Cut and disengage*, if made inside of the arm, is parried by quarte, or the counter in tierce; if outside, by tierce or counter in quarte. *Feint seconde* is another feint very nearly resembling *one, two*, and is generally made as a return after the parades of tierce, prime, or quinte. In this feint the octave or quinte is deceived; and it is parried by tierce, prime, or quarte, the two former being the readiest where quinte is the parade deceived, but if the feint has been answered with octave, the thrust must then be parried with quarte. The feint *one, two, three*, is made on either side of the blade, upon precisely the same principles as *one, two;* the only difference between them consisting in making one disengagement more in the latter than in the former movement. The *cut and one two* is a species of *one, two, three.* These feints, if made over the arm, are parried with the simple parade of tierce; if on the inside, with simple quarte. The other feints are, *doubling*, which, *mutatis mutandis*, is executed upon precisely the same principles; *one two and deceive the circle*, executed from the inside position of quarte; *one two and deceive the counter*, which may be made from either side of the blade, but is most frequently used commencing from the position of tierce; *feint flanconnade*, which can be commenced only from the engagement of quarte; *feint one two and deceive octave*, which is commenced either from the outside or inside engagement; *feint seconde and deceive quarte*, which is always commenced from the outside engagement, whether made as an attack or a return; *feint seconde and deceive tierce*, which differs from the preceding only in the last disengagement; *one two and deceive quarte from the position of the circle*, when the first disengagement is made over the adversary's wrist towards the body under the arm, and the second over the wrist towards the inside of the body; and *doubling on both sides of the arm*, which is too complicated a feint to be frequently used in actual fencing, because it is difficult to follow the adversary's sword with certainty through many different parades, and there is much danger of *time thrusts* upon feints which consist of so many disengagements.

Time thrusts are so called because the success of these movements depends entirely upon their being executed at the exact moment of time employed by the adversary in planning or in executing his attack; and, when made correctly, they are by far the most scientific movements in fencing. There are two sorts of time thrusts, in the execution of one of which it is necessary that the blades should cross each other, but for the completion of the other it is not absolutely necessary that the blades should even meet. Those time thrusts in the execution of which the blades cross are more scientific, and expose the fencer less to exchanged hits. There are two time thrusts *in opposition;* one the *time over the arm*, and the other the *time in octave.* The former is applicable to all thrusts, however simple or complex the feint may be, provided the longe is made upon the outside; whereas all longes directed to the inside of the body, or under the arm, are exposed to the time in octave; and thus almost every thrust made in fencing affords an opportunity for one or other of these two movements. Those time thrusts in which the opposition is not essential are made upon incorrect movements of the adversary, when he exposes himself by the wideness of his attacks, or by quitting the blade in a dangerous position, or by making too many disengagements in his feints, or by giving a variety of openings which the judgment of the fencer must determine how he is to take advantage of. This thrust is practised almost entirely upon irregular attacks, and requires great caution to be observed. It has been already stated, that time thrusts in opposition, when correctly made upon good attacks, are, perhaps, the finest movements in fencing; but young fencers should nevertheless attempt them very seldom, from the danger of misjudging the attack, and thus exposing themselves to the certainty of being hit. And the time out of opposition is attended with still greater hazard, as its success depends rather upon the wideness and irregularity of an adversary's movements, than on the security of one's own situation afforded by the opposition in the former species of time thrust.

When fencing was comparatively little known, it was thought necessary that there should be some intermediate practice for the pupil between the lesson of the master and his making the assault; for which purpose, it appears, he was taught to longe, at a proper distance, at the wall. This was called by the French *tirer au mur*, and was considered as useful for planting the learner well upon his legs, accustoming him to measure distance correctly, and causing his motions, in making his extension and longe, to follow one another in the proper succession. But as the art became better understood, observation induced masters to place pupils together for their mutual advantage, the one to attack by simple disengagements, the other to parry by quarte and tierce alternately; and this practice, from its origin, was for a considerable time called *tirer au mur*, a denomination which it still retains amongst fencers of the old school. It is now, however, generally known by the denomination of *quarte and tierce*, and, in its improved state, is not merely intended as an exercise for the scholar, but also as a graceful display of the principal motions of fencing; for which reason it should be invariably practised before commencing the assault, and in fencing before company it is never dispensed with. Quarte and tierce appears very simple in its execution, yet it is exceedingly useful to fencers in all stages of their progress, and difficult to acquire with such correctness that all its movements shall take place in their proper succession, and be made with the grace and precision characteristic of a good fencer. For a description of the method of thrusting quarte and tierce, we must refer the reader to the fifth chapter of Mr Roland's work, section first. The *counters* is also a practice of importance to young fencers, and should consequently be attended to by them.

In the language of the fencing-room, making the *assault* and *playing loose* are synonymous, signifying the practice of attack and defence, or, in other words, a just application of the lessons received, which, in fact, ought to be done as correctly as if with sword in hand. In the assault, the mere movements should be almost mechanical; for the mind being wholly employed in discovering and counteracting the designs of the adversary, as well as in concealing its own, the hand should, on the proper opportunity being given, instantly execute that which the mind conceives, without any consideration of the manner in which the particular motion is to be made, as loss of time would most probably prove fatal to its success. The rules to be observed are few and distinct. The first thing which the attention of a young fencer should naturally be directed to is, the most secure manner in which he can come into the position of the guard, when opposed to an adversary ready to take every advantage of his inexperience. Whilst advancing into distance, it is also an object of importance to have one side of the body secured by the position, particularly that side to which the antagonist's blade is opposed; so that, if he commence an attack during this movement, he must quit the blade in order to direct his thrust or feint at any opening afforded him by the position of his opponent; and the opportunities of attack being few, his designs will thus be the more easily discovered. In short, the commanding an opponent's blade almost obliges him to effect some change in the relative situations of the contending parties, before he advances into distance; and as the necessity of such previous movement must be foreseen, any attempt of this kind is favourable for making an attack on him. And, generally, whilst standing in the position of the guard, it is an advantage to have one side of the body covered, and to command the foible of the adversary's blade. Straight thrusts and simple disengagements, executed with quickness and vigour, should frequently be attempted, even though they do not succeed in hitting; and this counsel should be particularly attended to in fencing with a stranger. Quick simple thrusts are almost the only certain way of ascertaining his favourite parades, and consequently of knowing by what feints to attack him with a probability of success. The suddenness and rapidity of the attack will inevitably extort from him the secret of his favourite defence.

Many masters of the old school, and some, too, of the present day, have treated *disarming* as a matter of importance in the art; but, from its inutility, not to mention danger, in the field, it is now considered by the highest authorities on the subject as incompatible with good fencing. Mr Roland, in the work already referred to, shows by what methods this may be accomplished, and at the same time demonstrates the utter uselessness of the trick, for it is no better. The only advantage of disarming indeed is that of annoying the person disarmed; for, sword in hand, it is rendered nugatory by the use of a sword-knot, with which, it may be presumed, every person at all acquainted with the weapon will take especial care to fasten it to his wrist in a serious affair. As the manœuvre of disarming may therefore be defeated by the most ordinary precaution, attempting it can serve no other purpose than to make one play heavily and unpleasantly; whilst, from the strength it requires for the execution of its movements, it takes from the necessary quickness, and affords an adversary favourable moments of attack during the time an attempt is being made to bind his blade. In short, disarming is considered as characteristic of unskilful fencing; since perfection in the trick can only tend to render fencing disagreeable with the foil and ineffectual with the sword. We may add, that *volting*, *demi-volting*, *pirouetting*, parrying with and opposing the left hand, are manœuvres now totally disused in fencing.

As far back as 1692 a very curious book on the subject of fencing was published by Sir William Hope; it is now very scarce. In 1780 a Lieutenant M'Arthur published a work on fencing, which he dedicated to the Duke of Argyll, and which, we believe, is considered as a respectable performance. But since the latter period nothing worth noticing appears to have been written on the subject, with the exception of Angelo's book, illustrated by engravings, and the works of the two Rolands; of these, the most complete and satisfactory is Mr George Roland's *Treatise on the Theory and Practice of Fencing* above referred to. The only standard French works on the subject are, a Treatise by M. Danet, director of the royal academy of privileged fencing-masters; and one by M. Laboissier; both works of great merit, and highly esteemed in France.

FENELON, FRANÇOIS DE SALIGNAC DE LAMOTTE, was descended of an ancient and illustrious family, and born at the castle of Fénélon in Périgord, on the 6th of August 1651. Under the eyes of a virtuous father, he advanced in his literary studies with equal rapidity and success; and being from childhood nurtured in classical antiquity, and in particular familiarised in his solitude with the masterpieces of Grecian genius, his taste was formed on the purest models, whilst his benign genius was simultaneously developed. Called to Paris by his uncle, the Marquis of Fénélon, to complete his philosophical studies, and commence the course of theology requisite for the vocation to which he was destined, he, at the age of fifteen, underwent the same trial as Bossuet, and preached before an auditory, less distinguished, perhaps, than that which assembled in the hôtel de Rambouillet, but still highly respectable, who listened to him with a mixture of surprise and admiration. But this premature reputation rather alarmed than gratified the Marquis of Fénélon, who, in order to withdraw the young apostle from the seductions of the world and of glory, placed him in the seminary of St Sulpice. In this retreat Fénélon imbibed the evangelical spirit, and acquired the friendship of the virtuous Tronson, the superior of the establishment; and here also he received holy orders. About this time his religious fervour inspired him with the design of devoting himself to the missions in Canada. But being thwarted in this scheme by the apprehensions of his family and the weakness of his constitution, he soon turned his regards towards the missions of the Levant, particularly Greece, where the sacred and the profane, St Paul and Socrates, the church of Corinth, the Parthenon, and Parnassus, equally invited his poetical and religious imagination. Fortunately for the Catholic church and for France, however, this project also misgave; and Fénélon, diverted from distant missions, devoted himself to an apostleship, which he thought not less useful, namely, the instruction of the *Nouvelles Catholiques*, or newly-converted women in Paris. The duties and cares of this employment, in which he buried his genius during ten years, prepared him for the composition of his first work, entitled *Traité de l'Education des Filles*, a masterpiece of delicacy and of reason, which has not been equalled by the author of *Emile* and painter of Sophie. This work was intended for the Duchess of Beauvilliers, the pious mother of a numerous family. In the modest obscurity of his ministry, Fénélon had already formed with the Dukes of Beauvilliers and of Chevreuse that virtuous friendship which resisted equally the seductions of favour and the frowns of disgrace, the smiles of the court and the decree of exile. But in the case of Bossuet he met with an attachment which was destined to be much less durable. Admitted into familiarity with this great man, Fénélon studied his genius and his life; and the example of Bossuet, whose polemical religion exercised itself in controversies and conversions, probably suggested to him the *Traité du Ministère des Pasteurs*, a work in which he combats the heretics with a moderation which formed no part of the character of his illustrious model. The subject, the merit of this work, and the all-powerful suffrage of Bossuet in its favour, induced Louis XIV. to confide to Fénélon the charge of a new mission to Poitou. The rigorous uniformity which the French monarch was desirous of establishing in matters of religion, and the resistance which sprung from the oppressive measures adopted for this purpose, often obliged the monarch to cause his missionaries be supported by troops. Fénélon, however, not only rejected peremptorily the co-operation of the dragoons, but even reserved to himself the choice of the ecclesiastical colleagues who should share with him in the ministry of persuasion and gentleness. He converted without persecuting, and made the faith of which he was the apostle an object of love instead of hatred. The importance which was then attached to such missions fixed all eyes upon Fénélon, who had so happily acquitted himself of that entrusted to his care.

A great object was now presented to his ambition and his talents. The dauphin, grandson of Louis XIV., had at length passed the period of childhood, and the king was looking out for a person to whom the education of the young prince might be confided. This was in the year 1689. By the favour of Madame de Maintenon, virtue obtained the preference in this appointment. M. de Beauvilliers was named governor, and he recommended to the king Fénélon as preceptor of the young prince. These virtuous friends, seconded by the attentions of men worthy of imitating them, commenced the task of educating the future king; and history attests that there was never seen a more perfect concurrence of principle and exertion. But Fénélon, by the natural superiority of his genius, formed the soul of this reunion; it was he who, transported by the hope of one day realizing the *beau ideal* of a prince on the throne, and viewing the happiness of France as in a great measure dependent on the education of its future sovereign, destroyed with admirable art all the dangerous germs which nature and the premature sentiment of power had implanted in his youthful breast, and gradually moulded an almost indomitable character to the habit of the most salutary virtues. This system of education, precious vestiges of which remain in some of the writings of Fénélon, appears to have been a masterpiece of that genius which devotes itself to advance the happiness of mankind. When brought into the midst of the court, Fénélon, without intermingling in its intrigues, secured general admiration by the graces of his brilliant and ready wit, and the charm of his noble and eloquent conversation. In his character the apostle and the great lord seemed to be strangely united. Imagination and genius escaped him on all occasions; and the most refined politeness at once embellished and rendered pardonable in the eyes of courtiers, the ascendency of his talents. This personal superiority indeed excited much more admiration than even the writings which proceeded from his pen, and, at the period of his reception in the Academy, was made the subject of eloquent commendation. "On sent," says La Bruyère, writing of him soon afterwards, "la force et l'ascendant de ce rare esprit, soit qu'il prêche de génie et sans préparation, soit qu'il prononce un discours étudié et oratoire, soit qu'il explique ses pensées dans la conversation ; toujours maître de l'oreille et du cœur de ceux qui l'écoutent, il ne leur permet pas d'envier ni tant d'élévation, ni tant de faculté de delicatesse de politesse." This ascendency of virtue, of grace, and of genius, which excited in the hearts of the friends of Fénélon a tenderness mixed with enthusiasm, and which had even won Madame de Maintenon, in spite of her distrust and reserve, proved altogether unavailing against the prepossessions of Louis XIV. This monarch no doubt esteemed the man to whom he had confided the education of his grandson, but he never had any relish for his society. It is supposed indeed that the brilliant and ready elocution of Fénélon was distasteful to Louis, intolerant as he was of any sort of pre-eminence except his own. But if we cast our eyes on the letter in which Fénélon, in an expansion of confidence, informed Madame de Maintenon "that Louis XIV. had no idea of his duties as a king," we shall probably find, in the expression of this honest but uncourtly opinion, a better explanation of the aversion of a monarch accustomed to adulation, than in any supposed jealousy of the superiority of his conversational powers. Fénélon passed five years in the eminent situation of preceptor to the dauphin, without asking or receiving any thing; and, indeed, during his residence at court he had preserved the most irreproachable disinterestedness. Louis XIV. however, who knew how to recompense merit, even though its possessor might not be personally agreeable to himself, wished to repair this oversight, and, in 1694, named Fénélon Archbishop of Cambrai.

But at this moment of favour and prosperity his credit was destined to receive a blow, which would have inflicted a mortal wound on a less inviolable reputation. Fénélon, whose natural temperament disposed him to cherish a lively and spiritual devotion, had for some time fancied that he recognised some of his own principles in the mouth of a pious mad woman, who, not doubt, had great talents for persuasion, since she obtained an extraordinary influence over several superior minds. Madame Guyon, writing and discoursing on grace and on pure love, at first persecuted and arrested, soon afterwards admitted into the intimate society of the Duke of Beauvilliers, received by Madame de Maintenon, and authorized to disseminate her doctrine in St Cyr, then suspected by Bossuet, arrested of new, interrogated, and condemned, served as a pretext for the disgrace of Fénélon. The inexorable Bossuet, who loved not the mystical subtilties and refinements concerning divine love, with which the lively and tender imagination of Fénélon was captivated, wished to bring it about that the new Archbishop of Cambrai should himself condemn the errors of a woman who had been his friend. Fénélon, however, refused, both from conscience and delicacy, to gratify his antagonist in this particular. Fearing to compromise opinions which were dear to him, wishing to manage and restrain an unfortunate woman, whose only offence appeared to consist in some venial exaggeration about the love of God, and perhaps also shocked at the theological haughtiness of Bossuet, who pressed upon him as if for the purpose of proselytism, he stood upon the defensive, and published his *Maximes des Saintes*, which may be regarded as an indirect apology for, or even as a subdued exposition of, the principles of Madame Guyon. In an age when a religious opinion was a political event, the first appearance of this work excited murmurs of astonishment; and all those who had been secretly envious of the genius and the promotion of Fénélon, declared loudly against the errors of his theology. Bossuet, a man incapable of indulging mean or unworthy sentiments, but at the same time inflexible, impatient of contradiction, and regardless of all external observances, when he believed the faith to be compromised, denounced to Louis XIV. in the midst of his court, the alleged heresy of the Archbishop of Cambrai; and at the moment when this attack was made upon Fénélon, the burning of his palace at Cambrai, and the consequent loss of his library, manuscripts, and papers, put his patience to a new trial, yet only drew from him the touching remark, "It is better that the fire should have consumed my dwelling than the cottage of a poor labourer." Nevertheless Bossuet, committed by his declaration to the king, prepared to pursue his rival, and seemed eager to extort from him a recantation; whilst, on the other hand, Madame de Maintenon, hitherto the friend and protectress of Fénélon, treated him with the greatest coldness. In the mean time Fénélon submitted his book to the judgment of the holy see. Bossuet, however, having already composed remarks, in which bitter and vehement censure is surrounded with ostentatious expressions of friendship and regret, proposed a conference; but this Fénélon declined, preferring to defend his book at the tribunal to which he had appealed. It was then that he received orders to quit the court and retire into his diocese; a circumstance which occasioned great grief to the Duke of Burgundy. The cabal wished to profit by the fall of Fénélon to overthrow the Duke of Beauvilliers; but the latter was saved by his own virtuous conduct; for his devotion to the cause his unfortunate friend interested the generosity of Louis XIV. and their design miscarried. Notwithstanding the evident desire of this monarch, however, the court of Rome hesitated to condemn an archbishop so illustrious as Fénélon. But the repugnance evinced by Innocent VIII. only served to stimulate the talents of the accuser and accused; and, whilst the judges (a commission consisting of ten cardinals) remained undecided, the writings of the two adversaries succeeded one another with prodigious rapidity. The contest had, in fact, now changed its character. After having exhausted the dogma, Bossuet threw himself upon the facts; and the *Relation du Quiétisme*, written with equal spirit and malignity, seemed calculated to involve Fénélon in a portion of the ridicule which inseparably attached to Madame Guyon. The Abbé Bossuet, an unworthy nephew of the Bishop of Meaux, extended still further these personal inculpations, and, having collected some odious rumours, sought to impeach the purity of Fénélon's character. Never did the indignation of a virtuous and calumniated spirit display itself in greater eloquence. Fénélon, in his defence, demolished these vile accusations; and it required new letters from Louis XIV. prepared by Bossuet, and new intrigues, carried even to the extent of menace, to extort from the court of Rome a reluctant condemnation, which, when obtained, was found to be softened both in the form and in the expressions.[1] But the long and glorious resistance of the Archbishop of Cambrai had exasperated to the utmost the resentment of Louis XIV.; and the hesitation of the court of Rome to condemn him rendered his disgrace at that of France more irrecoverable than ever. When the brief, so long delayed, and obtained after so much discussion and intrigue, at length arrived in 1699, Fénélon hastened to subscribe it, and to ratify his own condemnation by a mandatory letter, conceived in the most touching and simple language, although Bossuet did not fail to discover in it much parade and ambiguity.[2]

The modest submission of Fénélon, his silence, his episcopal virtues, and the admiration which these had inspired, would not, in all probability, have re-opened to him the doors of the court of Louis XIV.; but an unexpected event, which occurred at this time, served to irritate that monarch more than ever against him. The *Télémaque*, composed several years previously during the period of his favour, was published some months after the affair about Quietism, through the infidelity of a domestic who had been employed to transcribe the manuscript, and who, it appears, had contrived to take a copy for himself. The work, though suppressed in France, was reproduced by the presses of Holland, and obtained throughout all Europe a success which malignity rendered injurious to Louis XIV., by seeking in it allusions to the conquests and misfortunes of his reign. This prince, who had always disliked the political notions of Fénélon, and had even described him as "un bel esprit chimérique," regarded the author of *Télémaque* as a detractor of his glory, who to the guilt of ingratitude added the more irritating injustice of satire. There cannot be a greater absurdity, however, than to construe this production as a political satire, or to seek in it for allegorical and premeditated censure of Louis XIV.; all the details being, in fact, combined in the best manner imaginable for disconcerting allusions, and avoiding as much as possible the inevitable fatality of resemblances. We are convinced indeed that this generous precaution occupied the mind of Fénélon whilst composing the work, and that, writing for the happiness of nations, he selected those primitive manners, and antique forms of society, which are the most remote from the picture of life presented by modern Europe, but which served equally well to embody his poetical conception, and to suggest those instructive lessons which it was his grand object to inculcate. Besides, why should he have thought of representing Louis XIV. under the character of the imprudent Idomeneus, or that of the sacrilegious Adrastus, rather than under the masterly delineation of the great and virtuous Sesostris?

Fénélon, however, soon learned the indelible impression which *Télémaque* had produced upon the heart of the king; and, resigned to his banishment from court, which he had sometimes the weakness to call his disgrace, he sought to console himself for the loss of the royal favour by endeavouring to diffuse happiness around him in his retreat at Cambrai. The sanctity of the ancient bishops, the severity of the primitive church, the attraction of the most indulgent virtue, the charm of the most captivating politeness, the utmost eagerness to fulfil even the humblest duties of the ministry, indefatigable goodness, inexhaustible charity; such are the traits of Fénélon's character as delineated by an eloquent and virtuous prelate, who knew him well, and who dwells with enthusiasm on the picture which he has drawn of his illustrious friend. The first care of Fénélon was to instruct the clergy of a seminary which he had founded; nor did he even disdain to teach their catechism to the children of his diocese. Like the bishops of ancient days, he often ascended the pulpit of his cathedral, and, trusting at once to his faith and his feelings, spoke without preparation, diffusing all the treasures of his natural eloquence. When the misfortunes of the war, which chastised the ambition of Louis XIV., brought the allied army into the diocese of Cambrai, the occasion called for new efforts and new sacrifices upon the part of the good archbishop, who, by his wisdom, his firmness, and the nobleness of his language, inspired the hostile commanders with a salutary respect for the unfortunate provinces of Flanders. Marlborough and Eugène indeed were worthy of listening to the voice of the great man whose genius and worth they so well appreciated.[3]

The situation of Cambrai on the frontiers of France attracted to the archiepiscopal residence many strangers, none of whom approached or quitted its lord without being affected with a sort of religious admiration. Not to mention Ramsay, who passed several years under his roof, the celebrated Marshal Munich, and the unfortunate Chevalier de St George, called James III., experienced the delight of his society, and derived instruction from his superior sagacity. By the wise counsels which he gave to James III., Fénélon showed his high esteem for the English constitution, powerful alike against despotism on the one hand, and anarchy on the other. The archbishop was exempt from that narrow patriotism which undervalues whatever exists beyond the frontiers. His virtuous and benevolent spirit

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[1] The interest of this discussion, so foreign to the ideas of our age, has been admirably preserved in the excellent *History of Fénélon* by M. de Bausset, in which will be found an animated picture of the court of Rome and of the court of France, which took such a lively interest in this frivolous question, which, however, was aggrandized by the opinions of the time, and the prodigious talents of the rival disputants.

[2] Pope Innocent, who appears to have heartily disapproved the violent proceedings adopted against the Archbishop of Cambrai, wrote thus to the prelates who had particularly distinguished themselves as adversaries of Fénélon: *Peccavit excessu amoris divini, sed vos peccâstis defectu amoris proximi*; one of the most pungent reproofs, perhaps, which is to be found in all history.

[3] It is now known that the *Vie du Prince Eugène*, though written as if it were an autobiography in the first person, is the production of the Prince de Ligne. In this clever performance, the veteran is made to speak thus of the great preachers of his time: "Quand Bourdaloue me fait tout craindre, Massillon me fait tout espérer. Nous sommes nés la même année, et je l'ai connu à son entrée dans le monde, parfaitement aimable. Bossuet m'étonne; Fénélon me touche. Je les avais vus aussi dans ma jeunesse; et Marlborough et moi, nous avons rendu *au dernier* tous les honneurs possibles, quand nous avons pris Cambrai." (*Vie du Prince Eugène*, p. 225. Paris, 1810, 8vo.)

concerned itself for the welfare of the whole human family. "I love my family," said he, "better than myself; I love my country better than my family; but I love the human race better than my country." The humanity of Fénélon was not, however, confined to exaggerated speculations and impracticable generalities, which always suppose great ignorance of the details of human affairs. His politics were not the dream of a virtuous but fanciful mind. He had seen and judged both the court and the world; he was acquainted with the history of all ages; and he was endowed with an independence of spirit which raised him above the prejudices of his age and nation. In the different memoirs which he addressed to the Duke of Beauvilliers may be seen proofs of the wisdom of his views respecting the greatest interests, particularly the succession to the throne of Spain, the policy best suited to Philip V., the views of the allies, the conduct of the war, and the necessity of peace. The disastrous war of the succession having brought the theatre of action near to the archiepiscopal residence of Fénélon, afforded him an opportunity, after ten years' absence, of seeing the young prince whom he had formed, and who had just assumed the command of the French troops. It cannot be disguised, however, that, in the command of armies, the pupil of Fénélon fell far below the promise of his youth and the opinion of France respecting him. The letters of the archbishop to the Duke of Burgundy, at this decisive epoch, evince a severe frankness, and show the ascendency which the master had acquired over the mind of the scholar; so much so, indeed, as to create a suspicion that the young prince, though well informed, docile, and virtuous, was of too timid a genius. In these letters also severe judgments are pronounced on all the generals who then formed the hope of France. Fénélon, in fact, though he possessed great sweetness of disposition, had not a little of domination in his character. His ideas were absolute and decisive; the promptitude and force of his mind rendered his judgments energetic and inflexible. But the continual attention which he gave to the political interests of France in no degree diminished his zeal for the affairs of religion and the church; and those who have been accustomed to honour him as a philosopher, will perhaps be surprised to find him entering into all ecclesiastical discussions with an ardour equal to that of Bossuet himself. When the unfortunate disputes about Jansenism were, after a long interruption, revived, Fénélon wrote against men who did not imitate him in his respect for the court of Rome, and he soon found himself engaged in a controversy scarcely less animated than that which had taken place concerning Quietism.

The courtiers supposed that in acting thus Fénélon had views of ambition and flattery. But if he had desired to regain the favour of the sovereign, he employed, about the same period, a much more effectual method for accomplishing his object, by feeding at his own expense the whole French army during the disastrous winter of 1709. His aim in both cases was to serve religion and his country. The same sentiments dictated the view which he presented the following year of the evils of France, and also the project of associating the nation with the government, by convoking an assembly of the notables, a proposition remarkable in itself, and still more so when considered in connection with subsequent events. In the memoir which contains the exposition of this scheme, Fénélon shows that he had rightly estimated the strength and the weakness of despotism, as well as the salutary power of liberty. Meanwhile, an unexpected event appeared to accelerate the moment when the counsels of Fénélon were to govern France. The grand dauphin died, and the Duke of Burgundy, long oppressed by the mediocrity of his father, saw himself all at once brought close to the throne of which he was heir, and to the king, whose stay and support he now became. His virtues, freed from a jealous tutelage, had at length scope for action; and the pupil of Fénélon showed himself worthy of his master. Full of hope and joy, the latter wrote to the young prince, who, according to St Simon, reigned in advance, "Il ne faut pas que tous soient à un seul, mais un seul doit être à tous pour faire leur bonheur;" language which, we believe, has but rarely been addressed to the heirs apparent of thrones. But whilst Fénélon was devising plans for promoting the welfare of France, and advancing the glory of its future sovereign, all his hopes were blasted by the sudden death of the young heir of the old king, who remained unshaken amidst all the humiliations of his glory, and all the disasters of his family. Fénélon survived this event some time, and, notwithstanding his grief, laboured to prevent the evils incident to a long and inevitable minority. In several confidential memoirs which he wrote on this subject, we discover the novelty of his political views, and that spirit of liberty which, in his age, was not the least of its innovations. One of these papers is devoted to a discussion of the probabilities of the guilt of the Duke of Orleans, and whether he was actuated by an ambition which required other crimes besides that which had been laid to his charge; a memoir in which, without dwelling upon all the horrors of the popular reports, he judges severely the scandalous profligacy of the Duke of Orleans, and condemns his vices in the tone and language which it became a Christian bishop to assume. The last public discussion in which Fénélon engaged related to the bull *Unigenitus*, which, as is well known, gave rise to much controversy, and occupied his attention towards the close of his life. Malignity has supposed that the zeal of Fénélon in this matter was sharpened by an old grudge against the Cardinal de Noailles; but when the conduct of this virtuous and excellent man seems to be authorized by his duty, it is not necessary to explain it by reference to his alleged weaknesses. Faithful above all things to his episcopal character, he conceived himself bound to combat errors which he considered as calculated to disturb the consciences of men, and to interrupt the repose of the church. But his wine of life was now upon the lees. His friends, like the travellers on the bridge in the Vision of Mirza, had dropped off one by one, till the Duke of Beauvilliers alone remained to him; and when the latter was also removed by death, Fénélon followed him to the grave at the brief interval of four months. This great and good man expired on the 7th January 1715, at the age of sixty-four; and his death, which a slight fall had accelerated, was, like his life, that of a virtuous and exemplary Christian bishop. In the *Dissertations* prefixed to this work (vol. i. p. 335) the reader will find the characters of Fénélon and Bossuet ably contrasted, by Sir James Mackintosh.

The following list of the works of Fénélon includes every thing of any consequence which proceeded from his pen: 1. *Traité de l'Education des Filles*, 1681 and 1687; 2. *Traité du Ministère des Pasteurs*, 1688, in 12mo; 3. *Explication des Maximes des Saints*, 1697, in 12mo; 4. *Aventures de Télémaque*, 1699, the editions of which are innumerable; 5. *Dialogues des Morts, composés pour l'éducation d'un Prince*, 1712, in 12mo; 6. *Dialogues sur l'Eloquence en général, et sur celle de la Chaire en particulier, avec une Lettre à l'Académie Française*, 1718, in 12mo; 7. *Examen de la Conscience d'une Roi*, 1734; 8. *Lettres sur divers sujets, concernant la Religion et la Métaphysique*, 1718; 9. *Démonstration de l'Existence de Dieu, tirée de la connaissance de la Nature, et proportionée à la faible intelligence des plus simples*, 1713, in 12mo; 10. *Recueil de Sermons choisis sur différents sujets*, 1710, in 12mo; 11. *Œuvres Spirituelles*. There is no very complete edition of the works of Fénélon. The clergy of France undertook one some years before the Revolution, and entrusted the preparation of it first to the Abbé Gallard, and afterwards to the Abbé de Querbeuf; but, from whatever cause, in this collection of the writings of Fénélon, which appeared at Paris in nine volumes 4to, 1787–1792, the reader will seek in vain for those on Quietism and Jansenism, his *Explication des Maximes*, and his *Mandements*. In the edition of the *Œuvres de Fénélon*, published at Toulouse, 1809–1811, in nineteen vols. 12mo, the life of Fénélon by Querbeuf has been introduced, together with four *Instructions Pastorales*, and an *Abrégé des Vies des anciens Philosophes*, which are not contained in the former edition. Some years after the death of Fénélon there appeared *Recueil de quelques Opuscules de M. de Salignac de Lamotte-Fénélon, archevêque de Cambrai, sur différentes matières importantes*, in 8vo, a rare volume, which is precious as containing a detailed catalogue or notice of all his works, reprinted in the edition of *Les Aventures de Télémaque* published at Lyons in 1815. The éloge of Fénélon by D'Alembert will be found in the *Histoire des Membres de l'Académie Française* (tom. i. and iii.). That of Laharpe gained the prize proposed by the Academy, whilst the abbe obtained the *accessit*. But the most complete biographical account of this illustrious man is that given by M. de Bausset, formerly bishop of Alais, in his *Histoire de Fénélon*, 1808, in 3 vols. 8vo, reprinted the year following with corrections and additions. (A.)

FENTON, Sir Geoffrey, an eminent writer and statesman during the reigns of Elizabeth and James I., was brother to Edward Fenton, the navigator, who accompanied Sir Martin Frobisher in his expeditions, and was afterwards sent out independently to endeavour to discover a north-west passage. The time of Sir Geoffrey's birth is uncertain, but he appears to have received a liberal education, and certainly gave many proofs of his acquaintance with ancient and modern learning, particularly of his knowledge of the French, Spanish, and Italian languages. He is best known, however, for his translation of the *History of the Wars of Italy* by Guicciardini, which he dedicated to Queen Elizabeth. But this was his last work, as is proved by the date of the dedication (7th January 1579) just mentioned. He had previously published, 1. Certain Tragical Discourses, written oute of French and Latin, 1567, in 4to; 2. An Account of a dispute at Paris, between two Doctors of the Sorbonne and two Ministers of God's Word, 1571; 3. An Epistle, or Godly Admonition, sent to the Pastors of the Flemish Church at Antwerp, exhorting them to concord with other Ministers; translated from the original of Antonio de Carro, 1578; 4. Golden Epistles, containing variety of Discourses, both moral, philosophical, and divine, gathered as well out of the remainder of Guevara's works, as other authors, Latin, French, and Italian, 1577. The familiar epistles of Guevara had been published in English by Edward Fellowes, in 1574; but Fenton's collection consists of pieces not contained in that publication, and, like his translation of Guicciardini, has risen in public estimation since the language and literature of the Elizabethan age have been more generally studied. In the capacity of queen's counsellor or secretary, Fenton served for a considerable time in Ireland, where his conduct appears to have given great satisfaction to his royal mistress, and whence he was frequently sent for to be consulted respecting Irish affairs. Nor does the confidence which his sovereign had in his judgment and understanding appear to have been misplaced. Maintained in office by her favour alone, he repaid her kindness by communicating salutary truths, and recommending wise and liberal measures. To his honour be it stated, he took every opportunity of impressing on the mind of the queen the important truth, that the Irish were to be governed only by a strict observance of the rules of justice, and that the safety and glory of her government in that island depended on her subjects enjoying the protection of equal laws. How much misery, and suffering, and humiliation, might have been spared to Ireland, if succeeding counsellors and secretaries in that country had been capable of appreciating the enlightened policy so strongly recommended by Fenton! In 1603 Sir Geoffrey married his only daughter to Mr Boyle, afterwards Earl of Cork, and died at his house in Dublin on the 19th October 1606. (A.)

Fenton, *Elijah*, an English poet of considerable note, was born at Shelton, near Newcastle-under-Line, in Staffordshire, on the 20th May 1683. Being the youngest of twelve children, he was destined for the church as a profession; and with this view, after passing through the usual course of grammatical education, he was, on the 1st July 1700, admitted a pensioner of Jesus College, Cambridge, where he prosecuted his studies with much diligence and assiduity; but having refused to take the oaths to government, he was obliged to quit the university without a degree, and forced to trust to his abilities for a subsistence. Whatever were the difficulties and discouragements which he had to struggle with, however, Fenton never descended to mean or dishonourable shifts; and as his conduct was without reproach, so his name was never mentioned except with commendation. His first employment promised more than it afterwards realized. He accompanied the Earl of Orrery to Flanders in the capacity of private secretary, and returned with his lordship to England in 1705. Being thus left without employment, he became assistant in a school at Headley, in Surrey, and was soon afterwards appointed master of the free grammar-school at Sevenoaks in Kent. In 1710 he was prevailed on to give up the drudgery of teaching, for the worse drudgery of political dependence; Lord Bolingbroke, who had persuaded him to take this unwise step, having, with characteristic recklessness, neglected his interest, and left him disappointed and in debt. But not long afterwards he was appointed tutor to Lord Broghill, only son of the Earl of Orrery; and when this engagement expired, he was, on the recommendation of Pope, employed to give private instructions to Mr Craggs, secretary of state, who, feeling his own want of literature, was anxious, with the aid of such an instructor, to supply the deficiencies of his education. The sudden death of Craggs, however, disappointed the expectations which had been formed from this connection, and Fenton was again thrown out of employment. His next engagement was with Pope himself. The success of the translation of the Iliad having induced the latter to undertake that of the Odyssey, he, in order to lighten the task, resolved to engage auxiliaries; and, with this view, retaining twelve books for his own share, he distributed the remaining twelve between Broome and Fenton. Of these, according to Johnson and Warton, Fenton translated the first, fourth, nineteenth, and twentieth; though the Earl of Orrery has asserted that he translated double the number of books which Pope has acknowledged.[1] In 1723 his tragedy of *Mariamne* was brought out, and performed with such success that the author's profits are said to have amounted to nearly a thousand pounds. The poetical merit of this tragedy is considerable; but the

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[1] In a letter to Mr Duncombe, Lord Orrery says, "His reward was a trifle, an arrant trifle. He has even told me that he thought Pope feared him more than he loved him. He had no opinion of Pope's heart; and declared him, in the words of Bishop Atterbury, "*Mens curva in corpore curvo.*"

diction is too figurative and ornate for a dramatic composition, and accordingly it has not retained its place on the stage. In 1727, Fenton superintended a new edition of Milton's *Poems*, to which he prefixed a life, of which Johnson has spoken with commendation; and, in 1729, he published a splendid edition of Waller, with notes, which is accounted among the best of that poet's works. The latter part of Fenton's life was passed in tranquillity. By the recommendation of Pope, Lady Trumbull appointed him tutor to her son, first at home, and afterwards at Cambridge; and when he had acquitted himself of the duties of this office, she still retained him in her family as auditor of her accounts, in which capacity he seems to have enjoyed his ease, and found leisure to pay frequent visits to his literary friends in London. He died at East Hampstead, Berkshire, on the 13th July 1730, and was interred in the parish church, where his tomb bears inscribed on it an epitaph written by Pope. Fenton, naturally indolent, was capable of greater things than he performed. His reputation as a poet rests chiefly on his *Mariamne*, and his share in the translation of the *Odyssey*, which the readers of poetry have never been able to distinguish from the portion executed by Pope himself; but to his *Miscellaneous Poems*, published in 1717, he has been indebted for a place amongst the English poets in Dr Johnson's collection. Of his morals and conversation the account is uniform. "He was never named," says Dr Johnson, "but with praise and fondness, as a man in the highest degree amiable and excellent. Such was the character given of him by the Earl of Orrery, his pupil; such is the testimony of Pope; and such were the suffrages of all who could boast of his acquaintance." (A.)

FEOD, or FEUD. See FEUDAL LAW.

FEODOSIA, one of the circles into which the Russian province of Taurida is divided. It stretches along the eastern side of the peninsula which separates the Black Sea from the Sea of Azoph. It is a fertile tract of land, and was formerly much more thickly peopled, and much better cultivated, than it is at present. The chief place, known before the Russian possession by the name of Kaffa, but now by that of the province, is situated on a bay in the Black Sea, and has an excellent harbour, though not safe in the winter. It contains from 400 to 500 houses, and about 4500 inhabitants. It was declared a free port in 1806, since which period its inhabitants and trade have greatly increased. It is situated in latitude 45. 4. N. and longitude 35. 14. E.

FEOFFMENT, in *Law* (from the verb *feoffare* or *infeudare*, to give one a fief), the gift or grant of any corporeal hereditament to another. He who so gives, or enfeofs, is called the *feoffer*, and the person enfeoffed is denominated the *feoffee*.

FERALIA, in *Antiquity*, a festival observed amongst the Romans on the 21st February, or, according to Ovid, on the 17th of that month, in honour of the manes of their deceased friends and relations.

Varro derives the word from *inferi*, or from *fero*, on account of a repast carried to the sepulchres of such as had that day the last offices rendered to them. Festus derives it from *ferio*, on account of the victims sacrificed. Vossius observes that the Romans called death *fera*, cruel, and that hence might arise the word *feralia*. Macrobius (*Saturnalia*, lib. i. cap. 13), refers the origin of the ceremony to Numa Pompilius. Ovid, in his *Fasti*, goes back for its institution as far as the time of Æneas. He adds, that on the same day a sacrifice was performed to the goddess Muta, or Dumb; and that the persons who officiated were an old woman and a number of attendant young girls.

During the continuance of this festival, which lasted eleven days, presents were made at the graves of the deceased, marriages were forbidden, and the temples of the gods were shut. Whilst the ceremonies continued, it was imagined that the ghosts suffered no punishments in hell, but that their tormentors allowed them to wander round their tombs, and to feast upon the meats which their surviving friends had prepared for them.

At the feralia public feasts were sometimes given to the people, at the tombs of the rich and great, by their heirs or particular friends.

FER DE FOURCHETTE, in *Heraldry*, a cross having at each end a forked iron, like that formerly used by soldiers to rest their muskets on. It differs from the cross fourche, the ends of which were bent as well as forked; whereas, this has the same sort of fork fixed upon the square end. See HERALDRY.

FERAH, a town of Persia, in the province of Seistan, ninety miles north-north-east of Zareng, and a hundred and fifty west of Candahar. Long. 62. 22. E. Lat. 33. 20. N.

FERE, LA, a town of the department of the Aisne, in France, at the junction of the rivers Serre and Oise. It is strongly fortified, and has in it an establishment for educating artillery officers. It contains 436 houses, and 2604 inhabitants. Long. 3. 13. E. Lat. 49. 40. N.

FERENTARII, in Roman antiquity, were auxiliary troops, lightly armed, whose weapons were a sword, a bow and arrows, and a sling

FERETRIUS, a surname of Jupiter, *a ferendo*, because he had assisted the Romans; or *a feriendo*, because he had conquered their enemies under Romulus. He had at Rome a temple built by Romulus, to which the spoils called *opima* were always carried.

FERETRUM, amongst the Romans, the bier used in carrying out the bodies of the dead, a duty which was performed by the nearest male relations of the deceased. Thus, sons carried out their parents, brothers their sisters, and so on.

FERG, or FERGUE, FRANCIS PAUL, a landscape painter, was born at Vienna in 1689, and there learned the first principles of his art. He successively practised under Hans Graf, Orient, and Thiele. The last of these, who was painter to the court of Saxony, having invited him to Dresden to insert small figures in his landscapes, Ferg repaired to that city, whence he proceeded into Lower Saxony, and painted for the Duke of Brunswick and for the gallery of Salzdahl. From Germany he passed over to London, where he might have lived in esteem and affluence, if, by an indiscreet marriage, he had not been so effectually depressed, not to say degraded, that he was ever afterwards involved in difficulties. The necessities which arose out of his domestic troubles compelled him to diminish the prices of his paintings in order to procure immediate subsistence; and as these necessities increased, his pictures sunk still more in price, though not in intrinsic value. By a series of misfortunes, however, he became overwhelmed in debt, and, to avoid the pursuit of his creditors, was constrained to secrete himself in different parts of London. He died suddenly in the street one night as he was returning from some friends, about the year 1738, before he had attained his fiftieth year, and left four children wholly destitute. This pleasing artist, Mr Walpole observes, had formed a manner of his own from various Flemish painters, though resembling Poelemburg most in the enamelled softness and mellowness of his colouring; but his figures are greatly superior, every part of them being sufficiently finished, and every action expressive. He painted small landscapes, fairs, and rural meetings, with much natural truth; his horses and cattle are not inferior to those of Wouvermans; and his buildings and distances seem to owe their respective softness to the intervening air, not to the pencil. More faithful to nature than Denner, he knew how to omit exactness, when the result of the whole demanded less precision in parts. The greater number of his works are in London and Germany; and the price they now bear is the best proof of their real merit. He also etched well with aquafortis; and his prints of that description are generally esteemed by the curious.

FERGUSON, Adam, LL.D., a distinguished philosopher and historian, was born at Logierait, in the Highlands of Perthshire, on the 20th of June 1723. His father, the Reverend Adam Ferguson, a native of the neighbouring parish of Moulin, had been minister of Crathie and Braemar, in Aberdeenshire, from 1700 to 1714; but, on the eve of the rebellion under the Earl of Mar, had been translated to Logierait, where he passed the remainder of his long life, discharging the duties of his laborious charge with such exemplary piety, fidelity, and firmness, that, though at the period of his induction the parishioners were almost universally hostile to presbyterian principles, he speedily secured the respect and admiration of all ranks; and, till the close of his incumbency in 1754, retained a degree of influence which proved that his knowledge of mankind was not inferior to his zeal for their religious improvement. This excellent man left a numerous family, of whom Adam was his youngest son, by Mary Gordon, daughter of Mr Gordon of Hallhead, in Aberdeenshire.

It is believed that Adam received the first part of his education at the village school of his native parish, under the superintendence of Mr John Connacher, of whose literary attainments little can now be ascertained. Whatever may have been the merits of this teacher, they do not seem to have been estimated so highly as those of the schoolmasters of Dunkeld and Perth; to one or other of which places it was at this time customary for the parishioners of Logierait to send such of their sons as they wished to prepare for a course of academical study. Two, at least, of Mr Ferguson's younger sons attended the grammar-school of Perth, between the years 1732 and 1738, whilst Mr James Martin was rector, and Mr Andrew Cornfute one of the assistants. Under the tuition of these able and diligent instructors, Adam is said to have made uncommon progress in classical literature; and in addition to the benefit which he derived from his teachers, he possessed the advantage of living under the protection of a respectable citizen, Mr William Ferguson, his relative, a merchant in the town, and at one time chief magistrate or provost.

Towards the end of autumn 1738, when he had entered into his sixteenth year, he was removed from school to the University of St Andrews, where his father had commenced his studies fifty years before, under a very meritorious regent, Mr John Row, son of the minister of Ceres; who, being grandson of the well-known David Ferguson, minister of Dunfermline, was induced, by the claims of kindred as well as of duty, to pay particular attention to the improvement of a youth whom he soon discovered to be highly deserving of his favour. It so happened that one of the colleagues of Mr Row was still a master of St Leonard's College, and that all the other masters were of nearly the same standing with the elder Mr Ferguson, who was thus confirmed in his preference of the college in which he had prosecuted his own philosophical studies. At this very juncture the principal of St Leonard's College died, and the other professors, at whose almost unanimous recommendation Mr Tullideph was appointed to the vacant chair, anticipated the most prosperous results from his efforts to promote the good of an establishment which they considered as having fallen into disrepute, in consequence of the feeble and undignified administration of his predecessors.

The Greek class in St Leonard's College was at this time taught with great reputation by Mr Francis Pringle, who had obtained his office in 1699; but, though no other teacher of that language in Scotland could pretend to rival him, the average number of students who were received annually under his charge, from 1738 to 1747, did not exceed eleven; whilst the average of entries to the corresponding class in St Salvator's College scarcely amounted to six. Adam Ferguson was enrolled in Mr Pringle's class as a ternar, the same rank of students which, in the days of Buchanan, was characterized by the term *pauper;* that is to say, one who pays the lowest rate of fees. It has been alleged that Ferguson, after a comparative trial, was admitted one of the foundation bursars, having stood first in the list of successful competitors. If it were so, the victory was not very splendid, as, of the twelve who entered the class along with him, not more than eight (being of the denomination of ternars) could have been permitted to take a share of the contest.

Besides Pringle, the other masters in St Leonard's College were, John Craigie, admitted professor of philosophy in 1691; Ninian Young, professor of humanity, and Henry Rymer, professor of philosophy, both admitted in 1709; and David Young, professor of philosophy, admitted in 1716. Before the end of the session 1739, Charles Gregory, professor of mathematics, resigned in favour of his son David, who, though a very ordinary man, was the most popular teacher of geometry ever known in that university, which had many years before numbered amongst its professors the inventor of the reflecting telescope.

The method of teaching in St Leonard's College at this period did not materially differ from that which had been pursued in the former century. The professors in general followed the beaten track in which they had been guided by their predecessors; and the tasks which they exacted from the students were little more than exercises of memory. A young man of slender abilities might easily distinguish himself as much as his most ingenious associates, who, on the other hand, might be apt to underrate acquirements which were more accessible to plodding industry than to original talents. We have good reason to believe that Ferguson acquired little more at this seminary than a high admiration of the Grecian and Roman literature, to the beauties of which he was more nearly introduced than he had hitherto been; and that his advances in the knowledge of philosophy were all made at a subsequent period. Even under the vigilant and severe inspection of Principal Tullideph, the discipline of the college was by no means effective; and, in Mr Pringle's class particularly, some of the young gentlemen conducted themselves so improperly as to have narrowly escaped the disgrace of being refused their degrees, after they had undergone the usual trials. Mr Ferguson obtained the degree of master of arts on the 4th of May 1742, when he had nearly completed his nineteenth year. The regent under whom he finished his course of physical study was Mr David Young, who used as a text book Keill's *Introductio ad veram Physicam.*

The minister of Logierait had attempted to induce some of his other sons to follow his own profession; but as they had all testified a disinclination to this line of life, he determined to breed his youngest son to the church, and accordingly he was sent to the divinity hall at St Andrews, in November 1742, when the theological department of study was superintended by Principal Murison and Professors Shaw and Campbell, the last of whom, a man of talents and learning, was well known by his writings; but, like several of his predecessors in the same chair, he scarcely ever lectured at all. Mr Ferguson studied also a year or two at Edinburgh under Professors Gowdie and Cuming; but his attention appears to have been chiefly given to pursuits not immediately connected with his clerical views.

In the year 1745, when he had attended divinity only one half of the usual period, an appointment was offered to him, which he could not hold without ordination. It was, in fact, represented to the General Assembly that Lord John Murray, colonel of the Highland regiment (the 42d), was desirous of having a chaplain of the communion of the Church of Scotland possessed of the Erse language; and that Mr Adam Ferguson, though he had not studied divinity for the full period of six years, was pitched upon for that office, provided the Assembly would allow the presbytery of Dunkeld to take him on trials. The Assembly, in respect of the young man's capacity and good character, authorized the presbytery to ordain him on passing his first trials, and accordingly he was ordained at Dunkeld, on the 2d of July 1745. A few days afterwards he joined the regiment, in which he continued to serve till 1757; about the beginning of which year he was elected keeper of the Advocates' Library, on the resignation of the celebrated David Hume. About a year after, Mr Ferguson was succeeded in this office by Mr William Wallace, junior, advocate.

In the course of the year 1757, Mr Ferguson rendered himself conspicuous by the interest which he took in the success of the tragedy of *Douglas*, written by his friend Mr Home. He published a defence of the *morality of stage plays*, which, though its merit is not of the highest order, was admitted by the opposite party to be "the only piece on that side that was written with any tolerable degree of discretion." After Mr Home resigned his living in June 1757, Mr Ferguson and he retired to country lodgings at Braid, in the neighbourhood of Edinburgh, where they spent several months in a course of laborious study, enlivened by the intercourse of friendship. As Mr Ferguson's campaigning habits had reconciled him to a migratory life, it is not easy to trace him through all his changes of residence. During his father's lifetime he had great satisfaction in making occasional excursions to the Highlands, and thinking aloud in his solitary walks, amidst the lakes and forests of Rannoch, or on the summit of his native mountains, where one of the most magnificent prospects in nature was displayed before his eyes. It was here that the lofty enthusiasm of his spirit was nursed and matured; and it was not so much in the intercourse with polished society as in the wilds of Athole that he acquired that dignity and ease of manner for which he was distinguished above most of the literary men of his country. To use his own expressive words: "If I had not been in the Highlands of Scotland, I might be of their mind who think the inhabitants of Paris and Versailles the only polite people in the world. It is truly wonderful to see persons of every sex and age, who never travelled beyond the nearest mountain, possess themselves perfectly, perform acts of kindness with an aspect of dignity, and a perfect discernment of what is proper to oblige. This is seldom to be seen in our cities or in our capital; but a person among the mountains, who thinks himself nobly born, considers courtesy as the test of his rank. He never saw a superior, and does not know what it is to be embarrassed. He has an ingenuous deference for those who have seen more of the world than himself; but never saw the neglect of others assumed as a mark of superiority."

In the year 1759 he was elected professor of natural philosophy in the University of Edinburgh, in the room of Dr John Stewart. He had not made physical science the principal object of his inquiries; and indeed he had not studied it much more attentively than most young men do in the common routine of academical instruction. But with only four months to prepare for the labours of the winter, he qualified himself so well as to give universal satisfaction. He conducted this branch of education five years, and by adapting his lectures to the capacities of the young, contrived to render the study more interesting than it had been commonly considered. At this time he was a member of the well-known *Select Society* of Edinburgh, instituted in 1754, for the purpose of promoting philosophical discussion, and training the members to the practice of public speaking. The ardour of this society did not begin to languish till the year 1762, when another association, equally celebrated, was formed by the literary circle of Edinburgh, the design of which was to rouse the country to demand from the legislature the establishment of a militia in Scotland. Mr Ferguson may almost be considered as the founder of this society; and it was at his suggestion that it received a name (*The Poker*) which was sufficiently significant in the ears of the initiated, but utterly unintelligible by strangers. His satirical pamphlet entitled *The History of Sister Peg*, was intended to forward the object of this patriotic society; and it is perhaps the only production connected with that cause, which, at this distance of time, is capable of exciting any interest.

In 1763 Mr Ferguson was applied to by the Earl of Warwick, to take charge of his two younger sons, the Honourable Charles and Robert Greville, whose eldest brother, Lord Greville, had received part of his education under the eye of Principal Robertson. These young gentlemen resided some years in his house, and both they and their tutor Mr Macpherson repaid his attention to their improvement by the warmest affection and gratitude. Lord Warwick, who had been advised by General Clerk to place his sons under Mr Ferguson's care, was not insensible of the "great benefit they had reaped from his tuition, and advantageous as well as manly and friendly conversation." Mr, afterwards Sir John, Macpherson, at the same time acknowledged, that "to him he owed all his knowledge, as well as all his success in life."

On the appointment of Mr Balfour to the professorship of the law of nature and nations in 1764, Mr Ferguson was elected by the magistrates of Edinburgh to succeed him in the chair of moral philosophy. This had long been a favourite object of his ambition; and about ten years before, when the able and accomplished Mr Cleghorn was on his death-bed, he urged his young friend to apply for the office, which, in his apprehension, no man was more capable of adorning. Mr Cleghorn, after expressing his regret at having no such influence with the patrons as to secure such an arrangement, added, as Mr Ferguson sometimes related with much emotion, "I can only say of you, as Hamlet did of Fortinbras, *He has my dying voice.*"

Mr Ferguson entered on his new duties with a degree of spirit and activity, from which the most splendid results were to be anticipated. In one particular his mode of lecturing was singular, and not easily imitated. After having delineated the general plan of his course, and committed it to writing, he resolved not to write a system of lectures, but to endeavour to make himself master of every part of his subject, and to trust to the moment of delivery for the expression of his sentiments. This method of discoursing was in his hands very happily executed; but its success depended, in a great measure, on the state of his health and spirits, as well as upon the interest excited by the different subjects of discussion. Perhaps no lecturer, with the exception of his immediate successor, was ever more admired. His class was crowded by great numbers of gentlemen of high rank and official station, as well as by younger students. In the mean time, eagerly as he applied to the discharge of his professional duties, his attention was extended to other branches of inquiry; and within little more than a year after he commenced his labours as a lecturer on morals, he sent to the press his *Essay on the History of Civil Society*, a work which was received with an expression of public approbation which even exceeded the high expectations of his friends. "Ferguson's book," says Mr Hume, writing to Dr Robertson from London, "goes on here with great success." Gray the poet says, "There are uncommon strains of eloquence in it; and I was surprised to find not one single idiom of his country (I think) in the whole work." Mr Hume, in a letter to the author, (dated 10th March 1767), congratulates him on the success of the book, adding that he had "met with nobody that had read it who did not praise it. Lord Mansfield is very loud to that purpose in his Sunday societies. I heard Lord Chesterfield and Lord Lyttleton express the same sentiment; and, what is above all, Caddel, I am told, is already projecting a second edition of the same quarto size." Mr Hume then informs him, that Lord Shelburne and Lord Bute were amongst his most zealous partisans; the last declaring the book one of the best he had ever read. Charles Townshend appears to have been of the same opinion, as he read it five times.

General Clerk had pressed the author to dedicate his work to Lord Shelburne, who had signified his intention of offering Mr Ferguson the government of West Florida; upon which occasion his lordship laughed very heartily, when the general expressed his conviction that Mr Ferguson was more usefully employed as a teacher of science. The book, however, appeared without any dedication. In the course of the following year, Lord Shelburne intimated a hope of getting Mr Ferguson established with a proper appointment at Oxford; and some other persons of influence meditated a design of employing him in one of the departments of state. This purpose was frustrated in all probability by a temper which did not permit him to accommodate himself to the views of those whose maxims of conduct he did not entirely approve. Another circumstance may be considered as having also operated to obstruct the fulfilment of the schemes which were devised for his advancement. At this time he married Miss Burnet, a young lady nearly connected with his mother's family, and still more nearly related to his intimate friend Dr Black. Soon afterwards he began to cultivate a farm in the parish of Currie, and, at a considerable sacrifice of private interest, gratified his taste for improvement, by transforming a barren heath into a scene which became distinguished for beauty and fertility.

It was impossible, however, for any combination of circumstances to abate his literary activity; and he not only continued to conduct the business of his class with unremitted diligence, but seized every interval of leisure which he could command, to collect materials for a history of the Roman commonwealth. Whilst he was proceeding in his researches, he was solicited by Philip, Earl of Stanhope, the editor of Dr Robert Simson's posthumous works, and the other guardians of Charles, Earl of Chesterfield, to superintend the education of that young nobleman, then in his nineteenth year. The negotiation was conducted through the mediation of Dr Adam Smith, who, judging the offer to be advantageous to his friend, exerted himself with great earnestness to induce him to accept it. Lord Stanhope was extremely anxious to obtain the able services of Dr Ferguson without delay, as he conceived it to be of the utmost consequence to his young kinsman to be placed under the care of "a person so well qualified to complete the remaining part of his education, and to repair the neglects, omissions, and errors, which had unfortunately been committed in the former part of it." The proposal had originally been made early in the year 1773, and was renewed in December, soon after the commencement of the session of the college, when Dr Ferguson was engaged not only in teaching his own class, but also in lecturing on natural philosophy, the professorship of which had recently become vacant by the death of his relation Mr Russell. He was not able to prevail on the patrons to accept of a substitute to complete the labours of that session; but after obtaining leave of absence for the next session, he joined his young charge at Geneva in May 1774, and at first entertained hopes that his labours might prove beneficial. The connection, however, was not so agreeable as he expected, and it terminated about twelve months afterwards. In the mean time, he had very nearly been deprived of his office in the university. The town-council had, at his desire, appointed Mr John Bruce, then assistant and afterwards successor to Mr Stevenson, to teach the moral philosophy during the session 1774–1775; but before the conclusion of the session they thought fit to rescind this act, and to declare the office vacant. His friends in the university, particularly Drs Robertson, Blair, and Black, were exceedingly indignant at this proceeding; more especially as Sir John Pringle had been permitted to be several years absent; and at that very time the professors of mathematics and of the theory of medicine had both been allowed to discharge their duty by substitutes for two years without challenge or complaint. As the council, however, seemed to have determined to fill up the place by a new election, it became necessary for his friends to apply to the Court of Session to put a stop to their proceedings. "I have been much obliged," says he, in a letter to a friend, "to the general voice that was raised in my favour, as well as to the ardent zeal of particular friends. Ilay Campbell (afterwards Lord President) has given me proofs of friendship which I can never forget. Pulteney has behaved to me in every thing as he would have done at the beginning of the Poker Club. I have always been an advocate for mankind, and am a more determined one than ever; the fools and knaves are no more than necessary to give others something to do."

After his return, he continued, as formerly, to divide his time between his literary and agricultural pursuits, and engaged occasionally in the political controversies which agitated the country during the progress of the American war. Besides his pamphlet in answer to Dr Price's observations on liberty, he communicated his views from time to time to Sir William Pulteney, and other members of parliament; and when it was resolved by government to send out commissioners to quiet the disorders in the colonies, he was appointed secretary to the commission. It appears from a letter of General Putnam, dated July 1778, that the nomination of Dr Ferguson was very agreeable to the more intelligent part of the Americans, who, not without reason, were dissatisfied to find that the commissioners were fettered by restrictions, which rendered their appointment nugatory. "I am very sorry," he writes, "that the parliament of Great Britain is still so blind to their own and our interest, as to send Dr Ferguson and the rest of the worthy gentlemen over to America with limited power, and that to last only till July 1779, and then to be revoked by them if they think fit; by which means I am deprived of seeing your friend Dr Ferguson, which gives me great pain, as I always have heard of his being a gentleman of the first character for learning, good sense, and humanity." It is well known that the commissioners returned without accomplishing the object of their mission; but they had an opportunity of acquiring more useful information of the state and temper of the country than government had received in all the previous course of the contest. Whilst Dr Ferguson was absent during the session 1778–1779, his place was supplied by Mr Dugald Stewart, who, about five years afterwards, was destined to succeed him in the chair of moral philosophy.

In the year 1780 he was seized with an attack of apoplexy, which, though not violent, was nevertheless sufficient to alarm his friends for his safety. This formidable affection did not in the slightest degree impair the force of his understanding; and so abstemious did he afterwards become, as not only to secure himself against the recurrence of the disease, but to enjoy almost uninterrupted health for more than thirty years. As he could not now venture to lecture as formerly without the use of written notes, he therefore found it necessary to write out a course of instruction to be read during the remainder of his incumbency. In his endeavours to recover the substance of his lectures, he availed himself of the notes taken by intelligent young men, who had studied under him different sessions, and who might thus be expected to have preserved the various modes in which he had stated his doctrines, and the different arguments and illustrations by which he had happened to supply in one session what might have been omitted in another. But, in the prospect of soon relinquishing his office, it was scarcely conceivable that the compilation which he thus executed could possess all the excellencies which he was capable of imparting to it; more especially as he was now busy in carrying his great historical work through the press. This was the *History of the Progress and Termination of the Roman Republic*, in three volumes quarto, published in 1783, a book which not only delights by the clearness of its narrative and the boldness of its descriptions, but instructs and animates by profound and masterly delineations of character, as well as by the philosophical precision with which it traces the connection of events. It is written in that tone of high-minded enthusiasm, which, if it can only snatch from oblivion whatever is noble and generous in the record of human actions, regards the graces of style as objects merely of secondary account, and is chiefly studious of impressing the lessons of wisdom which may be gathered from the survey of distant ages.

The fatigues and anxieties of public teaching now became oppressive to his spirits, and not altogether favourable to his health; and he therefore deemed it expedient to resign his office in 1784, when he had completed his sixty-first year. Mr Dugald Stewart, then professor of mathematics, succeeded to his office; and in order to entitle Dr Ferguson to retain his salary, he was conjoined in the professorship of mathematics with Mr Playfair. He now proceeded to revise the notes of his lectures on ethics and politics, with a view to publication; and in 1792 the work appeared, under the title of *Principles of Moral and Political Science*. Though composed under disadvantageous circumstances, and though he has omitted many of the questions which were treated in his elementary course, it contains an admirable view of the systems both of ancient and modern philosophers, particularly respecting the foundations of moral approbation, and the sources of private happiness and public security. The authors to whose suggestions he was most indebted were Xenophon, Plato, and Aristotle, amongst the Greeks, Cicero and Seneca amongst the Latins, Epictetus and Antoninus amongst the later scholars of the Grecian school; and, amongst the moderns, Shaftesbury, Hutcheson, Montesquieu, and Adam Smith. It has been considered as a blameable omission in this work, that too slight notice is taken of the importance of religious principle; and the author, in fact, seems to have been aware that he had exposed himself to this objection. No man, however, was ever more anxious to establish the foundations of natural theology, and to strengthen the arguments for a future state; subjects on which the work abounds in passages of uncommon beauty.

After the publication of this work, Dr Ferguson, now in his seventieth year, resolved to pay a visit to the ancient metropolis of the world. He passed a short time at some of the principal cities of Europe, Berlin, Vienna, Florence, Naples, and Venice, and resided part of the winter 1793 at Rome, in all of which places his reception was extremely flattering. He was elected a member of the Academy of Berlin, as well as of other learned societies. Upon his return to Britain in 1794, he took up his residence at Nidpath Castle in Tweeddale, from which he soon removed to Hallyards in Manor Water. In this agreeable retreat he spent the next fourteen years of his life, a longer period than he had ever before resided in any one place. At last, however, when his sight and his hearing had in a great measure failed, he deemed it advisable to settle in a town, where he might occasionally enjoy the conversation of intelligent friends; and his early prepossessions induced him to settle at St Andrews. Here his strength gradually declined, but the vigour of his mind continued unimpaired as long as he lived. No man took a more lively interest in the great events which were then passing in the world, or contemplated more anxiously the consequences of the arduous struggle in which his country was engaged. He lived long enough to witness the triumphant issue of the contest; and after a short illness, he died on the 22d of February 1816, in the ninety-third year of his age, leaving three sons and three daughters.

In the various situations which it was his lot to occupy, he had uniformly conducted himself with a dignity and decision which bespoke the elevation and force of his mind. As a military chaplain, he happily united the strict decorum of the clerical character with the unembarrassed address of a man of the world; so that he at the same time secured the respect of the officers and the devoted attachment of the private soldiers. It was while accompanying the army on different expeditions, one of the first of which was an ill-conducted descent on the coast of Bretagne in 1745, that he applied his mind to study the art of war; and it cannot be denied that he excels particularly in the description of military evolutions. In private life his conversation was easy and elegant, and, among his intimate friends, enlivened by a fascinating gaiety and refinement of humour. He was not very patient of contradiction, however, and rather apt to testify his contempt of assumed superiority.

His writings are,

1. *A Sermon*, preached in the Erse language to his majesty's first Highland regiment of foot, commanded by Lord John Murray, at their cantonment at Camberwell, on the 18th day of December 1745. By the Rev. Mr A. F. chaplain to the said regiment, and translated by him into English for the use of a lady of quality in Scotland, at whose desire it is now published. London, 1746.

2. *The Morality of Stage Plays seriously considered.* Edinburgh, 1757.

3. *A Pamphlet on the Militia.* London, 1758.

4. *The History of the Proceedings in the case of Margaret, commonly called Sister Peg.* Three editions. London, 1762. Another, 1777.

5. *Analysis of Lectures on Mechanics.* Edinburgh.

6. *An Essay on the History of Civil Society.* London, 1767. This book has passed through many editions, and has been translated into almost all the European languages. A translation into German was published at Leipsig in 1768, under the title of *Bersuch uber die Geschichte der Burgerlichen Gesellschaft.* A French translation, by M. Bergier, was published in 1783.

7. *Analysis of Pneumatics and Moral Philosophy.* A German translation, by Mr Garve of Leipsig, is said to be well executed. Edinburgh, 1766. Fifty-five pages 12mo.

8. *Institutes of Moral Philosophy*, 1769; 319 pages 12mo. Another edition, revised and corrected, 1773; 294 pages. A translation of this edition into French was published at Geneva in 1775, and it had the advantage of being revised by the author. A third edition, enlarged, was published at

Edinburgh, 1785; 317 pages 12mo. This elementary work has been used as a text book in several foreign universities. A translation into the Russian language (from the German) was printed at Moscow in 1804.

9. Remarks on a pamphlet lately published by Dr Price, entitled *Observations on the Nature of Civil Liberty, &c.* in a letter from a gentleman in the country to a member of Parliament. London, 1776. These remarks having been addressed to Sir Grey Cooper, secretary of the treasury, were printed by his direction.

10. *The History of the Progress and Termination of the Roman Republic.* London, 1783. 3 vols. 4to. A translation into German was printed at Leipsig in 1784. It has been translated into several other modern languages, and has passed through a number of English editions, one of which was printed at Basel, in Switzerland, in 1791.

11. *Principles of Moral and Political Science,* being chiefly a retrospect of lectures delivered in the College of Edinburgh. London, 1792. 2 vols. 4to.

12. *Minutes of the Life and Character of Joseph Black, M. D.* 1801. (Published in the *Transactions of the Royal Society of Edinburgh.*)

13. *Biographical Sketch, or Memoir of Lieutenant-Colonel Patrick Ferguson.* Edinburgh, 1817. This tract, though printed, has not been published for sale.

He left behind him many papers on the subjects which had chiefly occupied his thoughts from the time of his last academical appointment; but a great mass of letters and other valuable documents had been indiscriminately destroyed by his direction some years before his death. (P. P. P.)

FERGUSON, *James*, an eminent experimental philosopher, mechanist, and astronomer, was born in Banffshire, Scotland, in 1714. His parents were very poor. At an early age, however, his extraordinary genius began to unfold itself. He first learned to read by overhearing his father teach his elder brother; and he had made this acquisition before any one suspected he had done so. He soon discovered a peculiar taste for mechanics, which first indicated itself on seeing his father use a lever; and having pursued this study a considerable time, even when very young, he at length made a watch in wood work, from having once seen one. As he had no instructor, nor any help from books, every thing he learned had all the merit of an original discovery; and such in fact he very naturally believed it to be. As soon as his age permitted he went out to service; but he met with hardships in this humble capacity, which rendered his constitution feeble through life. Whilst he was servant to a farmer, whose goodness he acknowledges in the modest account of himself which he prefixed to his *Mechanical Exercises*, he frequently contemplated the stars; and he began the study of astronomy by laying down, from his own observations alone, a celestial globe. His kind master observing these marks of his ingenuity, procured him the countenance and assistance of some neighbouring gentlemen, by whose help and instructions he went on acquiring further knowledge, and was at length sent to Edinburgh. There, having obtained some notion of drawing, he began to take portraits in miniature, by which means he supported himself and family for several years, both in Scotland and England, whilst engaged in pursuing more serious studies. In London he first published some curious astronomical tables and calculations, and afterwards gave public lectures on experimental philosophy, which he repeated in most of the principal towns in England with general approbation. He was elected a fellow of the Royal Society without paying for admission; and he had a pension of L.50 per annum given him, unsolicited, by King George III. on his accession, who had heard his lectures, and who frequently sent for and conversed with him on curious topics. He also received several presents from his majesty, and from other patrons of merit. The degree of consideration which Mr Ferguson attained by the strength of his natural genius alone is in fact known to every one. He was universally considered as at the head of astronomy and mechanics in this nation of philosophers; and he might justly be styled self-taught, or rather heaven-taught; for in his whole life he had not received above half a year's instruction at school. He was a man of the clearest judgment and the most unwearied application to study; benevolent, gentle, and innocent in his manners as a child; humble, courteous, and communicative; and, instead of pedantry, philosophy seemed to have produced in him only diffidence and urbanity. He died in 1776, at the age of sixty-two.

The following is a list of Mr Ferguson's published works: 1. Astronomical Tables, and Precepts for calculating the true times of New and Full Moon, 1763; 2. Tables and Tracts relative to several Arts and Sciences; 3. An easy Introduction to Astronomy, 1769, second edition; 4. Astronomy explained upon Sir Isaac Newton's Principles, 1772, fifth edition; 5. Lectures on select subjects in Mechanics, Hydrostatics, Pneumatics, and Optics, 1772, fourth edition; 6. Select Mechanical Exercises, with a short account of the Life of the Author by himself, 1773; 7. The Art of Drawing in Perspective made easy, 1775; 8. An Introduction to Electricity, 1775; 9. Two Letters to the Reverend Mr John Kennedy, 1775; 10. A Third Letter to the Reverend Mr John Kennedy, 1775. Mr Ferguson also communicated several papers to the Royal Society, which were printed in their Transactions. In 1805, a valuable edition of his Lectures was published at Edinburgh by Dr, now Sir David, Brewster, in two volumes 8vo, with notes and an appendix, intended to adapt the whole to the actual state of science.

FERGUSON, *Robert*, a Scottish poet, who acquired a considerable share of celebrity at a very early period of life, was born at Edinburgh on the 5th of September 1750 or 1751. His father, whose name was William, paid court to the muses as well as the son; but he wisely relinquished the study of poetry for the more certain emoluments of trade and commerce, and was employed in different mercantile houses both in Edinburgh and in Aberdeen. He was an accountant in the Linen Hall when he died, but never acquired any thing like an independent fortune.

The subject of this notice was of a weak and delicate constitution during infancy, so much so, indeed, that small hopes were entertained of his ever reaching the years of manhood. Yet such were the care and attention of his parents, that he was able to attend an English school by the time he was six years of age, when his progress was considered as very extraordinary; and it proved no less rapid at the High School of Edinburgh, which he attended for four years, acquiring a competent knowledge of the Latin tongue with very little labour or exertion. He then went to the grammar school of Dundee, and in two years afterwards to the university of St Andrews, which his father preferred to Edinburgh, because a gentleman of the name of Ferguson had left two bursaries for the education of as many boys of the same name.

Ferguson's health was never at any time impaired by severe study; yet he kept alive at the university the opinion which had been entertained of him whilst at school, and he was decidedly the first mathematician of his own standing. He was patronized by Dr Wilkie, professor of natural philosophy, but better known as the author of the *Epigoniad*, who conceived an attachment for him, as much perhaps for his poetical as his mathematical talents. This kindness was repaid by Ferguson, on the death of Dr Wilkie, by a beautiful eclogue to his memory, written in the Scottish dialect. A little before he left the university, Ferguson had conceived the idea of writing a tragedy on the death of Sir William Wallace, for which he had collected materials; but as he subsequently met with a work on the same subject, he abandoned the design, after he had completed two acts. His own reason for so doing is thus expressed: "Whatever I publish shall be original, and this tragedy might be considered as a copy."

He returned to Edinburgh when he had finished his studies, without having fixed on any particular employment; for although he was destined for the church by his father, on the death of the latter he paid but little attention to the expostulations of his mother. He also declined to enter on the study of physic, assigning as a reason, that when he read the description of diseases, he believed that he felt the symptoms of them all in himself. He was, however, induced to attempt the study of the law, in which, as might have been expected, he made no proficiency. He seems, however, to have turned a wishful eye to some sinecure place, in order to obtain which he paid a visit to an uncle who resided at Aberdeen, a man of literature and opulence, hoping that, through his influence, he might be settled in a manner suited to his merit. But in this expectation he was completely disappointed; for although his uncle at first showed him every mark of attachment, his fondness decreased by degrees, and in six months he desired his nephew in an abrupt manner to leave his house, without attempting to procure for him any kind of living.

His necessities at this period were so great that he copied papers in the commissary clerk's office for so much per sheet, an employment which he soon left in disgust. His exuberant wit, equalled only by his good nature, thoughtlessness, and social propensities, made all who knew him receive him with affection; but his powers of song and talents for mimicry often led him into the company of the dissipated, whose example could not fail to do him essential injury, and who had neither the power nor the inclination to provide for him through life. The irregularities in which he was thus led to indulge often awakened in him the reproaches of conscience; and the conversation of a minister, who understood his manner of life, appears to have made a deep impression on his mind. His remorse indeed soon afterwards assumed the appearance of absolute despair. His sprightliness entirely forsook him; but he gradually recovered from this despondency, and his health was at length fully restored. Soon afterwards he cut his head so severely in consequence of a fall, that he became delirious from the loss of blood; and in this condition he remained for some months, till the want of sleep and perpetual talking put a period to his existence on the 16th of October 1774. He was buried in the Canongate churchyard. Over his grave a monument was erected by Robert Burns, who loved his genius, and naturally sympathized with failings akin to his own. Had Ferguson united prudence with his abilities, he would have no doubt risen to distinguished eminence in the literary world. His poems in the Scottish dialect have been universally admired by his countrymen; and when we reflect that they were composed in the intervals of dissipation, they must be considered as unequivocal evidences of his genius.

FERIA, in the Roman Catholic breviary, is applied to the several days of the week; thus Monday is the *feria secunda*, and Tuesday the *feria tertia*, though these days are not working days, but holidays. The occasion of this was, that the first Christians were accustomed to keep the Easter week holy, calling Sunday the *prima feria*, and so on; hence the term *feria* was given to the days of every week. But besides these, there were extraordinary *feriæ*, as the three last days of Passion-week, the two following Easter-day, and the second *feriæ* of Rogation.

FERIÆ, in Roman antiquity, holidays, or days upon which the people abstained from work. Proclamation was generally made by the herald, by command of the *Rex Sacrorum* or *Flamines*, that all should abstain from business; and whoever transgressed the order was severely fined.

The *feriæ* were of two kinds; public and private. The public *feriæ* were fourfold: first, *Stativæ*, which were kept as public feasts by the whole city upon certain immoveable days appointed by their calendar, as the *Compitalia*, *Carmentalia*, and *Lupercalia*; secondly, *Feriæ Conceptivæ*, which were moveable feasts, the days for the celebration of which were fixed by the magistrates or priests, as the *Feriæ Latinæ*, *Paganalia*, *Compitalia*, and others, which happened every year, though the days for observing them were left to the discretion of the magistrates or priests; thirdly, *Feriæ Imperativæ*, which were instituted by the mere command of consuls, prætors, or dictators, upon the gaining of some victory or other fortunate event; and, fourthly, *Nundinæ*. The *private* feriæ were holidays observed by particular persons or families, on several accounts, as birth-days, funerals, and the like. The *feriæ* belonged to and formed one division of the *dies festi*.

FERIÆ *Latinæ*, a festival at which a white bull was usually sacrificed. On this occasion the Latin and Roman towns provided each a quantity of meat, wine, and fruits; and during the celebration, the Romans and Latins swore eternal friendship to each other, taking home a piece of the victim to every town. The festival was instituted by Tarquinius Superbus, when, having overcome the Etruscans and made a league with the Latins, he proposed to build a common temple to Jupiter Latialis, at which both nations might meet and offer sacrifices for their common safety. At first the solemnity lasted but one day, but it was at different times extended to ten days. It was held on the Alban Mount, and celebrated with chariot races at the capitol, where the victor was treated with a large draught of wormwood drink.

FERIANA, the ancient city of Thala in Africa, which was taken and destroyed by Metellus in the war with Jugurtha. It was visited by Bruce in his travels through Africa, and he expected to find many magnificent ruins in the place, but was disappointed.

FERMANAGH, a county in the south-western part of the province of Ulster, in Ireland, is bounded on the north by the counties of Donegal and Tyrone, on the east by the county of Monaghan, on the south by the counties of Cavan and Leitrim, and on the west by those of Leitrim and Donegal. It extends over a surface of 471,348 acres, of which 320,999 are arable land, 101,952 are mountain and bog, and 48,797 are under water.

In the time of Ptolemy it was inhabited by the tribe of the Darini. Afterwards it came into the possession of the Maguires, the O'Flanagans, and the O'Reillys; the first-named of which families had the greatest share of property and influence, and its head was looked upon as the dynast or chieftain of the territory. On the settlement of Ulster in the commencement of the reign of James I. the English family of the Coles was ranked among the principal residents. The county was made shire-ground, along with the rest of Ulster, by Elizabeth, when it was divided into the eight baronies of which it consists at present, viz. Clonkelly, Coole, Glenawly, Knockninny, Lurg, Magheraboy, Maghera-Stephana, and Tyrkennedy. These baronies are subdivided into eighteen parishes and six parts of parishes, the remaining parts of which are included within some of the adjoining counties. According to the ecclesiastical arrangements of Ireland, the chief portion of this county is in the diocese of Clogher; three parishes only being in the adjoining diocese of Kilmore.

The surface is very uneven. The borders towards Tyrone and Cavan, on the east, are mountainous. The north-western portion towards Leitrim presents one continuous mass of hills, many of them high, rough, and boggy, amongst which Belmore Mountain, swelling out its massive sides towards Lough Erne, stands proudly conspicuous. From the summit of the Tossid Mountain is a most extensive prospect, commanding the view of several counties, and taking in the whole of the lake just mentioned. Quilca Mountain, partly in this county and partly in Cavan, rises to a very considerable height. The hills on the south-eastern side of the lough are disposed more in ridges than those near them in the adjoining county of Cavan.

The great feature of the county is Lough Erne, which divides it nearly throughout its whole extent from north-west to south-east. This fine sheet of water forms two long lakes, connected by a strait, on which the town of Enniskillen is situated. They are distinguished by the names of the Upper and Lower Lakes. The former, or the more inland, which lies between Belturbet and Enniskillen, is eleven miles in length, and from half a mile to six miles in width. The latter, which lies between Enniskillen and Belleek, is thirteen miles long, and from two to ten broad. The borders of both are finely broken by numerous bays and inlets, formed by the projections of the surrounding mountains and hills. Both parts of the lake are studded with numerous islands. Popular report makes the number of these equal to that of the days of the year; and, if all the detached points of rock or land visible above water were taken into the account, this number would not be above the truth. There are not, however, more than a hundred and fifty of them which deserve the name of islands. They are in general well formed for scenic effect, and many of them are planted, chiefly with ash and oak, even to the water's verge. Part of the Upper Lake is so much crowded with them as to give it the appearance, in some parts, more of a flooded country than of an extensive sheet of water. The islands in the Lower Lake are more numerous and picturesque. The largest is Bo or Cow Island, so called from being employed as pasturage; it is situated near the western extremity of the lake. But Devenish Island, near its eastern end, though smaller, is much more celebrated, from having on it one of the most perfect pillar towers in Ireland. Its height is eighty-two feet, and its circumference forty-nine. It is built of cut stone, and finished at the top with a conical roof. Near the summit of the hill which forms the island is the abbey of St Mary's, of which the belfry staircase and some of the Gothic pillars still remain. At the foot of the hill is a church dedicated to St Molush; and in its vicinity are the remains of that saint's house, roofed and finished with cut stone. Within a few paces of the house is a stone trough, about six feet long, said to have been his bed, in which those affected with various complaints perform certain prescribed ceremonies, in the hope of obtaining relief. In the island of Ennism'saint are the ruins of an abbey founded by St Nevnid, whose festival is annually celebrated in it. The saint's bell, ornamented with gold and silver, is still preserved in the island, and held in such veneration as to be used as a relic to swear upon. In the same island is a burying-ground, having a large stone cross at its entrance. Innismore is the largest island in the Upper Lake. Belle-isle, containing about two hundred acres, once the favourite residence of the Earl of Ross, and celebrated as well for its natural beauties as for the taste displayed in its improvements, has been suffered to fall into such decay that scarcely a vestige remains of what it once had been. It is connected with the main land by a bridge. Innisharkey Island, near the village of Crum, has been the residence of the representative of the Erne family since the destruction of Crum Castle. The navigation of the lake is chiefly carried on by small vessels called cotts, about ten feet long below, flat-bottomed, with upright sides, and sloping outwards at the stem and stern, so as to allow them to be brought close to the shallow margin of the lake. They are worked by oars; and a broad paddle at the stern serves instead of a rudder. This lake has been pointed out by a late celebrated engineer as an excellent station for steam navigation, although steamers cannot pass from it to Ballyshannon by the Erne, in consequence of the numerous cascades and rapids in that river. Neither is the harbour of Ballyshannon an advantageous site. The course of the steamers should be from Lough Erne through Lough Melvin, and by Manor Hamilton to Sligo; and thence to communicate with the head of the Shannon. Two other lines of inland navigation have been projected, commencing at Lough Erne, and terminating, the one eastwards at Lough Neagh, the other northwards at Lough Foyle; but nothing has as yet been effected towards the accomplishment of either of them. There are some smaller lakes in the county, the largest of which are Lough Melvin, on the borders of Leitrim, and Lough Macnean or Cane, on the confines of Cavan and Leitrim.

The only river of any importance is the Erne, which rises in the county of Cavan, and after passing through Belturbet, falls into Lough Erne at its south-eastern extremity; thence, passing by Enniskillen, it enters the Lower Lake, at the north-western extremity of which it again narrows into a river, and, passing through Belleek, forms a fine water-fall, bursting out through a thick wood in a broad sheet; and afterwards breaking over a ledge of shelving rocks, it foams through the arches of the bridge here thrown over it, after which it becomes more tranquil; yet, still maintaining a rapid current, during a course of nine miles, in which it crosses many lesser ridges of rock, it at length precipitates its water down a noble cataract into the Atlantic at Ballyshannon. The other remarkable rivers are, the Arney, the Ballenclarogh, the Ballycassidy, the Clodagh, the Kish Water, the Moorlaugh, and the Sillas; all of which, together with upwards of fifty smaller streams, contribute to the supply of Lough Erne.

The geological structure of the county consists of sandstone and secondary limestone, alternating with tolerable regularity. Red standstone exists in Tossid Mountain. Yellow sandstone, well adapted for building, lies round the town of Enniskillen. Limestone may be found in several of the islands in Lough Erne. A beautiful species of brown marble is found near Florence-court, a limestone district; but it requires to be worked to a greater depth than at present, in order to procure blocks and slabs free from flaws. Coal is said to have been raised in Glengarron Hills; but as no effort has lately been made to procure this mineral there, notwithstanding the avidity with which mines of every description have been sought out and purchased up, it may be inferred that it is not to be had in sufficient quantities to render it an article of general consumption. The cheapness of turf fuel, which is to be had in all parts, is another reason why coal is not more sought after.

Mineral springs are numerous. Rutty gives a list of nineteen, mostly sulphureous, but none are much frequented by strangers; the superior character of the waters of Swadlingbar, in the adjoining county of Cavan, having prevented any successful rivalry.

The population of this county has increased prodigiously from the period in which the subject became an object of special inquiry. According to the several authorities by which it has been ascertained, its progress is as follows:

1760, De Burgo	28,860
1792, Beaufort	71,800
1812, Parliamentary census	111,800
1821, Ditto	130,997
1831, Ditto	149,555

As far as these authorities can be relied on, it appears that the population has increased five-fold in little more than seventy years. At present it exhibits an average of one inhabitant to every three acres of land generally, and to every two cultivable acres.

The state of education, according to the returns made under the population act in 1821, and to those of the Board of Education in 1824–26, is as follows:

	Boys.	Girls.	Sex not ascertained.	Total.
1821	4032	2303	—	6335
1824–6	5685	3848	260	9793

Of the numbers in the latter return, 5283 were of the established church, 246 were Roman Catholics, and 4204 dissenters, whilst the religious persuasion of sixty was not ascertained. Eighteen schools, containing 1012 pupils, were supported by grants of public money; fifty-nine, containing 3433 pupils, by voluntary subscription; and the remaining 163 schools, containing 5348 pupils, were wholly maintained by the fees of the pupils. As far as the proportions between the religious persuasion of the pupils can be applied as a scale for estimating the adult population, the Catholic portion of it must be extremely small, not constituting more than one-fiftieth of the whole, the remaining forty-nine parts being divided in nearly equal proportions between the Protestants of the established church and the dissenters. But in deducing this inference, due allowance should be made for the circumstance, that the Catholic population chiefly prevails in the mountainous districts, in which the desire for education is more checked by local obstacles than in those parts nearer the towns and the general channels of communication.

Previously to the Union, the county was represented in the Irish parliament by four members, two of whom were returned for the county at large, and two for the borough of Enniskillen. At that period the number was reduced to three, one having been deducted from Enniskillen. No alteration has been produced by the reform act.

The state of the constituency at three periods, the first, before the disfranchisement of the forty-shilling freeholders, which took place on the passing of the Catholic relief bill; the second, subsequent to that event, but previously to the passing of the reform bill; and the third, exhibiting its present state, will appear from the following table:

	L.50.	L.20.	L.10.	40s.	Total.
1st Jan. 1829	252	183	...	6443	6878
1830	254	256	522	...	1032
1832	178	250	1001	...	1429

Of the last-named number of electors, 1015 voted at the first election under the reform act.

This county is almost exclusively agricultural. Farms vary from nine acres, chiefly under tillage, to large tracts for grazing. Much land is let in the gross to middle-men, who sublet it to smaller tenants. Landowners of this description are distinguished by the name of terny-begs, or little landlords. Tiernagh is the Irish word for a prince. There is much land belonging to the see of Clogher in the county. Rents are paid in the mountainous districts in young cattle, yarn, and butter. Oats and barley are the kinds of grain chiefly raised; wheat is comparatively little grown. The manures are, marl, limestone, limestone gravel, bog-mold, and bog-ashes. The marl is white and light, found under bogs and in banks. That about Florence-court is upon clay and gravel, with springs under it, which cause the marl to run into forms like cinders petrified, and of a reddish cast, as if from vitriolic acid. Marl is but little used in farming, limestone and gravel being found more productive. Land is generally prepared for potatoes by manuring it with dung, or with lime and bog-mud mixed, and with burnt clay, which is found to answer well. Some excellent pasture lands are grazed both by black cattle and sheep. A small breed of cows is to be met with in all parts. The general stock of sheep is of an inferior kind; neither is there any thing like a flock to be seen. Goats are common, in consequence of the ease with which they are maintained in the mountain pastures. Twenty of these are not counted as a *sum*, the term used in this county to signify the keep of a cow, or the quantity of land requisite to feed one. The hilly country affords coarse pasturage for large herds of young cattle; yet that it could be made still more productive by being brought under tillage, is evinced from the success which has attended every judicious effort of industry when thus directed. Timber is more general in Fermanagh than in some of the neighbouring counties. Beech grows to a large size. Ash is a tree peculiarly abundant, both here and in the adjoining counties of Cavan and Tyrone. In the first-mentioned of these counties, indeed, it is constantly found in the hedgerows; and, more particularly in the northern side of Lough Erne, it runs like a weed through the county.

The linen manufacture is carried on here to some extent. The principal kind made is what is termed seven-eighths. There are several bleachfields in different parts. A good deal of wool is also spun, which is generally worked up into druggets, the warp being of tow yarn and the weft of wool. It is chiefly consumed within the county. These manufactures, and the rearing of black cattle, may be considered as the main sources of wealth among the small farmers.

The fish chiefly taken in Lough Erne and its tributary streams are, pike, perch, white and speckled trout, bream, red roach, pullein, salmon, and eels both silver and mud, much esteemed for the excellence of their flavour. There are several large eel-weirs at Enniskillen, where great quantities of these fish are caught. They come from the sea when young, and are intercepted in their return. They never take the bait, nor are they known to take any kind of food. The country people catch them by extending across the stream a band of hay, in which they are so entangled that they are easily taken. Their average weight is about three pounds. Those not sold fresh or sent to Dublin are carried in barrels, each of which contains eight dozen, and are sold in Belturbet. Eighty dozen are sometimes caught in a night. There is also an eel-weir near the falls of Belleek.

Fermanagh has a few resident proprietors of high rank or large income. They are all members of the established church, and derive their titles to their estates from Elizabeth, James I., or Cromwell. A class of yeomanry is also to be met with, who distinguish themselves by the character of being "as good Protestants as any in Ireland;" a phrase implying not so much any superiority in religious qualifications, as a rooted aversion to their Roman Catholic neighbours. These are farmers, who hold tracts of land of considerable extent, and were settled in the county when the right to the elective franchise was exclusively in the hands of Protestants. At that period, Catholic tenants were often turned out of their farms, and sent farther up the mountains, to make room for the privileged class. The Protestants are a fine race of men, much superior in appearance to those of any other of the northern counties. This superiority arises, in all probability, from their habits of life, which, being peculiarly agricultural, with very little intermixture of sedentary employment at manufactures, are more favourable to the free expansion of the bodily powers. They are tall, well made, and robust. Their countenances display the bloom of health; and they enjoy that uninterrupted flow of animal spirits which is the constant attendant on regular living and active employment. Yet, whether from custom or natural propensity, the peasants do not rise early, and the cows are not milked till noon. There being but few markets for the produce of the soil, little encouragement is given to extraordinary exertion; they therefore seldom think of turning their time to the best advantage. The cottars are poor, and their cabins wretched huts, with a wattled door, and a mat on the inside. Yet many of the herdsmen who reside in the mountains are able to give their daughters on their marriage twenty guineas and a feather bed, although the cabins in which they reside are of the wretched description just mentioned, and seem to contain nothing but dirt and wretchedness. In cases of disease the lower classes have no confidence in medicine. When they send for the physician, they consider themselves as having signed their death warrant. An aversion is therefore entertained to the whole medical profession; and those who would not lay out sixpence in an apothecary's shop will hoard up considerable sums to provide for the expenses of a wake. The custom of assembling round the body of a deceased friend prevails universally amongst the Catholics of all ranks; but it is declining every year more and more amongst the Protestants.

The seats of the gentry are very splendid. The principal are, Castle Caldwell, a fine mansion at the foot of a large mountain, having in front the promontory of Rossagoul projecting into the lake, which is here studded with several fine islands; Florence-court, the seat of the Earl of Enniskillen, the façade of which, of the Ionic order, extends 260 feet; Belle-isle, already noticed; Castle Saunderson, near which are some druidical monuments; Dromcoo, Castlecoole, Castle Archdall, Brookborough, and Crum, where there is an extraordinary yew tree, which throws out branches to the distance of forty-five feet.

The towns in this county are few and small, none amounting in population to 6000 souls, and but two having more than 1000 souls each. Enniskillen, the county town, is situated on an island in the strait or river that connects the two portions of Lough Erne. As it was one of the great passes from Ulster into Connaught, it has always been considered as a place of importance. During the war of 1688 it was particularly celebrated for the stand it made against the forces of James II. At a very early period it was the seat of the chief of the Maguire family, the remains of whose castle still exist, having been converted into an artillery barrack. The town occupies the whole island, and is connected with the main land on both sides by a bridge at each end of the High Street. The parish church is a venerable structure, on an elevated position. There is also a Roman Catholic chapel, and three dissenting meeting-houses. The exterior of the county infirmary presents the appearance of a private gentleman's seat. The market-house is a light and graceful building, ornamented with a steeple, and containing a suite of rooms for balls and assemblies. The court-house is a plain, grave edifice. The other public buildings are the infantry barrack and the county jail, in the latter of which the prisoners, who are all clothed in a prison-uniform, and arranged in four classes, are employed in breaking stones. A school is kept in it; and the females are superintended by a matron. There is also a tread-mill. The average number of prisoners for the last few years has been seventy. At a small distance from the town is the public school founded by Charles I. who endowed it with an estate of 3360 acres. The head master receives a salary of L.500 per annum, with other advantages. The town maintains a good corn, butter, and flesh-market, which last is held in convenient shambles. The environs of the town are very beautiful. It opens on the view in a manner peculiarly fine from Florence-court. The hill above the town was formerly planted. A French engineer, sent over by Lord Pelham, cleared it of wood, and erected a fort on it, which, after it had been built, was discovered to be completely commanded by higher ground in the neighbourhood. Enniskillen is celebrated as a depôt for obtaining recruits for the army. A regiment of horse was raised here in the time of King William, which is still distinguished by the name of the Enniskillen dragoons. This circumstance, together with the general habits and character of the peasantry, has tended to keep up a military spirit throughout the county. There are few families which have not one or more sons in the army. Young men who intend to enlist travel from very distant parts to this town, where they are sure to meet with recruiting parties to receive them. The population of Enniskillen in 1821 was 2399; in 1831 it was returned at 5270. The only other town containing more than a thousand inhabitants is Irvinestown, formerly Lowtherstown, the population of which, according to the census of 1831, amounted to 1047. The other collections of houses are mere villages, nor are there many even of these.

FERMAT, Pierre de, equally celebrated as a restorer of ancient mathematics, and an original author of modern improvements, was born at Toulouse about 1595. His public life was occupied by the active duties attached to the situation of a counsellor of the parliament of Toulouse, in which he was distinguished both for legal knowledge and for strict integrity of conduct. Besides the sciences, which were the principal objects of his private studies, he was an accomplished scholar, an excellent linguist, and even a respectable poet.

His *Opera Mathematica* were published at Toulouse, in two volumes folio, 1670 and 1679; they are now become very scarce. The first contains the *Arithmetic of Diophantus*, illustrated by a commentary, and enlarged by a multitude of additional propositions. In the second we find a *Method or the Quadrature of Parabolas* of all kinds, and a *Treatise on Maxima and Minima, on Tangents, and on Centres of Gravity*; containing the same solutions of a variety of problems as were afterwards incorporated into the more extensive method of fluxions, by Newton and Leibnitz; and securing to their author, in common with Cavalleri, Roberval, Descartes, Wallis, Barrow, and Sluse, an ample share of the glory of having immediately prepared the way for the gigantic steps of those illustrious philosophers. The same volume contains also several other treatises on *Geometric Loci*, or *Spherical Tangencies*, and on the *Rectification of Curves*, besides a restoration of *Apollonius's Plane Loci*; together with the author's correspondence, addressed to Descartes, Pascal, Roberval, Huygens, and others.

It was too much Fermat's custom to leave his most important propositions wholly undemonstrated; sometimes, perhaps, because he may have obtained them rather by induction than by a connected train of reasoning; and, in other cases, for the purpose of proposing them as a trial of strength to his contemporaries. The deficiency, however, has in many instances been supplied by the elaborate investigations of Euler and Lagrange, who have thought it no degradation to their refined talents to go back a century in search of these elegant intricacies, which appeared to require further illustration. It happened not uncommonly, that the want of a more explicit statement of the grounds of his discoveries deprived Fermat, in the opinion of his rivals, of the credit justly due to him for accuracy and originality. It was thus that Descartes attempted to correct his method of *maxima* and *minima*, and could never be persuaded that Fermat's first propositions on the subject were unexceptionable. Fermat was however enabled to pursue his favourite studies with less interruption than Descartes; and the products of his labour were proportionate, as Lacroix remarks, to the opportunities he enjoyed, as well as to the talents he possessed.

There is a very ingenious proposition of Fermat, which deserves to be particularly noticed, on account of the discussion that it not long ago excited among mathematical philosophers. He has demonstrated that the true law of the refraction of light may be deduced from the principle, that it describes the path by which it can arrive in the shortest possible time from any one point of its tract or course to another; on the supposition, however, that the velocity of light is inversely proportional to the refractive density of the medium: and the same phenomena of refraction have been shown by Maupertuis to be deducible, upon the opposite supposition with respect to the velocities, from the law of the minimum of action, considering the action as the product of the space described into the velocity. But the law of Fermat is actually a step in the process of nature, according to the conditions of the system to which it belongs in its original form; whilst that of Maupertuis is at most only an interesting commentary on the operation of an accelerating force. It was Newton who showed the necessary connection between the action of such a force and the actual law of refraction; demonstrating that all the phenomena might be derived from the effect of a constant attraction, perpendicular to the surface of the medium: and, except in conjunction with such a force, the law of Maupertuis would even lead to a false result. For if we supposed a medium acting on a ray of light with two variable forces, one perpendicular to the surface, and the other parallel to it, we might easily combine them in such a manner as to obtain a constant velocity within the medium, but the refraction would be very different from that which is observed, though the law of Maupertuis would indicate no difference; so that the law must be here applied with the tacit condition that the refractive force is perpendicular to the surface. In Laplace's theory of extraordinary refraction, on the contrary, the tacit condition is, that the force must *not* be perpendicular to the surface; so that this theory not only requires the gratuitous assumption of a different velocity for every different obliquity, which is made an express postulate, but also the implicit admission of the existence of a force, determinate in direction and in magnitude, by which that velocity is modified, and without which the law of Maupertuis would cease to be applicable. It may indeed be said, that the supposition of a medium exhibiting unequal velocities, and attracting the light perpendicularly, is unnatural, and that the law is the more valuable for not being applicable to it; but a mathematical equation is true even with respect to impossible quantities, and a physical law, however useful it may be, requires physical proof; and it will not be asserted that the law of Maupertuis has been or can be established by physical evidence sufficiently extensive to render it universal.

Fermat died at Toulouse in the end of 1664, or beginning of 1665, at the age of seventy. He left a son, Samuel de Fermat, who was a man of some learning, and published translations of several Greek authors. (L. L.)

FERMENT, any body which, being applied to another, produces fermentation.

Ferments are either matters already in the act of fermentation, or those which soon pass into this state. Of the first kind are the flowers of wine, yeast, fermenting beer, or fermenting wine, and of the second are the newly-expressed vegetable juices of summer fruit.

Amongst distillers ferments are all those bodies which, when added to the liquor, only correct some fault in it, and, by removing some obstacle to fermentation, forward the process by secondary means; also such as, being added in time of fermentation, make the liquor yield a larger proportion of spirit, and give it a finer flavour.

FERMENTATION may be defined a sensible internal motion of the constituent particles of a fluid, mixed, or compound body; by the continuance of which motion these particles are gradually removed from their former situation or combination, and again, after some visible separation is made, combined together in a different order and arrangement, so that a new compound is formed, having qualities very sensibly differing from those of the original fluid. See BREWING and CHEMISTRY.

FERMO, one of the delegations of the papal dominions, in Italy, 580 square miles in extent. It contains one city, eleven market-towns, and thirty villages, with 77,089 inhabitants. It is situated on the shore of the Adriatic, and on that side is fruitful in wheat, maize, pease, beans, and fruit, and produces some silk. On the western side it consists of the Appennines, and is less fertile. The capital, of the same name, is about two miles from the shore, where is Porto Fermo, whence several fisheries are carried on. The city is surrounded with walls, and contains ten churches, besides the cathedral of the archbishop, eleven monasteries, and five nunneries. The inhabitants amounted in 1816 to 19,678, and are occupied in various trades. Long. 13. 36. 21. E. Lat. 43. 10. 18. N.

FERMOSELLE, a town of Spain, in the province of Leon, with an ancient castle adjoining it. The river Duero passes by it a little above the part at which the Tormes, that flows by Salamanca, joins that river. This town possesses a population of 3000 souls.

FERNANDO, or FERNANDES, an island in the Pacific Ocean. See JUAN FERNANDES.

FERNANDO DE NORONHA, or NARONHO, an island in the Atlantic Ocean, situated about 210 miles from the coast of Brazil. It is only about three miles in length, and is full of mountains, which, however, are clothed with verdure. It possesses a fort, which is garrisoned; but the island is of little use, except as a place of banishment for male criminals. Long. 32. 28. W. Lat. 3. 56. S.

FERNANDO PO, an African island, situated near the coast of Benin. It was discovered in 1471 by a Portuguese navigator, whose name it bears. It is about sixty miles in circumference, and is both fertile and beautiful, yielding abundance of rice, fruit, sugar canes, and tobacco. It is however little frequented by strangers; and the inhabitants, who are about 1200 in number, are said to be rude and uncivilized. Long. 8. 40. E. Lat. 3. 28. N.

FERNANDO SAN D'APURE, a town of South America, in the province of Caraccas. It is situated on the great river Apure, and is chiefly inhabited by shepherds; who pasture their flocks and herds upon the surrounding plains. The population has been estimated at about 6000.

FERNELIUS, JOHN, physician to Henry II. king of France, was born at Picardy towards the close of the fifteenth or beginning of the sixteenth century. Being sent to Paris to study rhetoric and philosophy, he applied himself so intensely that all other pleasures became insipid, and he cared neither for play, nor walking, nor entertainments, nor even conversation. He read Cicero, Plato, and Aristotle, and also applied himself earnestly to the mathematics. This continual study brought on an attack of sickness, which obliged him to leave Paris. On his recovery he returned, designing to study physic; but before he had an opportunity of applying himself to this pursuit he was employed to teach philosophy in the college of St Barbara. After this he spent four years in the study of physic; and having taken a doctor's degree, confined himself to his closet, in order to read the best authors, and to improve himself in the mathematics, as far as the business of his profession would permit. Never, in fact, was there a man more diligent than Fernel. He used to rise at four o'clock in the morning, and study till it was time either to read lectures or to visit his patients. But as attending patients did not occupy his whole time, he read public lectures upon Hippocrates and Galen, which soon gained him a great reputation throughout France and in foreign countries. When his business increased, however, he left off reading lectures, and spent all the hours he could spare in composing a work on physic, entitled *Physiologia*, which was soon afterwards published. But he was prevailed with to read lectures upon this new work, which he did for three years; and having published another work, *De Venæ Sectione*, he was under the necessity of reading lectures some years longer, in order to explain this new book to his pupils. Whilst thus employed, he was sent for to court, in order to try whether he could cure a lady whose recovery was despaired of; and being fortunate enough to succeed, this circumstance was the cause of the esteem which Henry II., then dauphin, and in love with that lady, conceived for him. This prince offered him the place of first physician; but Fernel, who preferred his studies to the bustle of a court, respectfully declined the employment. When Henry came to the throne, he renewed his entreaties; but Fernel represented that the honour offered him was due, as an hereditary right, to the late king's physician, and that, besides, he required time to make experiments concerning several matters relating to medicine. The king admitted the validity of this excuse; but as soon as the physician of Francis I. died, Fernel was called to occupy his place at the court of Henry II. And here the contrary of what he had apprehended came to pass; for he enjoyed more leisure at court than he had done at Paris; and he might have considered it as an agreeable retirement, had it not been for the journey which the new civil war obliged the king to undertake. Fernel died in 1558, leaving behind him many works besides those which have been mentioned. They have been printed several times, with his life prefixed, written by William Plantius, his disciple.

FERNEY, a town of France, in the department of the Ain, and arrondissement of Gex. It is situated on an elevated spot, not far from the lake of Geneva, and contains 750 inhabitants. It is only remarkable from the château there having been the residence of Voltaire from 1762 to 1777.

FEROKABAD, a town of Hindustan, on the coast of Malabar, which was taken by the British under Colonel Hartley, in 1790. It is ten miles south of Calicut.

FERONIA, the pagan goddess of woods and orchards. This deity took her name from the town of Feronia, situated at the foot of Mount Soracte in Italy, where a wood and temple were consecrated to her worship. Both are mentioned by Virgil in the catalogue of Turnus's forces. Strabo relates that those who sacrificed to this goddess walked barefoot upon burning coals, without being hurt. Feronia was the guardian deity of freed men, who received their cap of liberty at her temple.

FEROZEGUR, a town of Hindustan, belonging to the Nizam, in the province of Beeder, 120 miles south-west by south from Hyderabad. Long. 77. 22. E. Lat. 16. 8. N.

FEROZEPOOR, a town of Hindustan, in the Sikk territories, in the province of Lahore, fifty-two miles south by east from the city of Lahore. Long. 75. 58. E. Lat. 31. 5. N

FERRAH, a large walled town of Afghanistan, situated in a fertile valley, which was visited by Captain Christie. It gives name to a considerable river, which falls into the lake of Zarra, and is supposed to be the Parrah of ancient Parthia, a place of great splendour and extent. Long. 61. 40. E. Lat. 33. 7. N.

FERRAJO-Porto, a city, the capital of the Isle of Elba, in the Mediterranean. It is situated on a rocky projection into the sea, to which there is but one accessible passage from the land. It contains 3143 inhabitants; but since the departure of Bonaparte, is again become a mere place for the fishery. Long. 9. 55. E. Lat. 42. 49. N.

FERRARA, one of the delegations of the papal dominions in Italy, which extends over 1210 square miles. It contains two cities, thirteen market-towns, and 254 villages, with 170,727 inhabitants. The greater portion of the district is the delta formed by the mouths of the Po, and is very unhealthy; but it is fertile, and produces good crops of wheat, rice, maize, hemp, flax, oil, and silk. The breed of cattle is very good; the dairy is extensively followed, and produces excellent cheese. There are two fortified places, which are occupied by Austrian garrisons. The capital is a city of the same name, situated on a branch of the Po, one of the finest in Italy, with broad and regular streets; but the houses and magnificent palaces are nevertheless very thinly inhabited. It contains, besides the cathedral, 100 churches, twenty-two monasteries, sixteen nunneries, and 5100 houses, but only 23,100 inhabitants. The university has been destroyed. There is little or no trade, and no manufactures. The citadel is garrisoned by Austrian troops. Long. 11. 31. 5. E. Lat. 44. 49. 56. N.

FERRARS, George, was descended from an ancient family in Hertfordshire, and born about the year 1510, at a village near St Alban's. He was educated at Oxford, and thence removed to Lincoln's Inn, where, having applied with uncommon diligence to the study of the law, he soon became distinguished for his elocution at the bar. Cromwell, earl of Essex, the great minister of Henry VIII. introduced him to the king, who employed him as his menial servant, and in 1535 gave him a grant of the manor of Flamstead, in his native county. This is supposed to have been a profitable estate; but Mr Ferrars being a gay courtier, and probably an expensive man, about seven years afterwards he was taken on execution by a sheriff's officer, for a debt of two hundred merks, and lodged in the compter. Being at this time member for Plymouth, the House of Commons immediately interfered, and he soon obtained his liberty. He continued in favour with the king till the end of his reign; and in that of Edward VI. he attended the lord protector Somerset as a commissioner of the army, in his expedition to Scotland in 1548. In the same reign, the young king being then at Greenwich, Mr Ferrars was proclaimed Lord of Misrule, that is, prince of sports and pastimes; which office he discharged during twelve days, in Christmas holidays, to the entire satisfaction of the court. This is all that is known of Mr Ferrars, excepting that he died in 1579, at Flamstead in Hertfordshire, and was buried in the parish church. He was not less celebrated for his valour in the field than for his accomplishments as a gentleman and a scholar, and he wrote, 1. History of the Reign of Queen Mary, published in Grafton's Chronicle, 1569, fol.; and, 2. Six tragedies, or dramatic poems, published in a book called the *Mirror for Magistrates*, first printed in 1559, afterwards in 1587, and again in 1610.

FERREANAH, a town of Tunis, in Africa. It bears evident traces of great antiquity, and of having been formerly the largest city of this portion of the Tunisian territory. This, it is usually affirmed, is somewhat unaccountable, because, though the town enjoys a good climate, and is well supplied with water, yet the surrounding country is arid and barren in the highest degree. But the difficulty vanishes when we consider that it lies in the vicinity of a great desert of sand, which is perpetually shifting, and gradually overwhelming whole tracts of country, which were formerly covered with luxuriant vegetation. Such may have been the case with regard to the country surrounding Ferreanah. Dr Shaw conjectures that it is the site of the ancient Thala, which is so particularly described by Sallust in his narrative of the Jugurthan war. Ferreanah is about 130 miles south-west of Tunis.

FERRETTO, in glass-making, a substance which serves to colour glass.

FERRO, or Hiero, the most westerly of the Canary Islands, and, besides being the smallest, also the most arid and barren. It has a population of about 5000 souls, and a superficies of twenty square miles. The coast is rugged, and the soil contiguous to it is barren; but in the interior the face of the country improves, and there is a considerable portion of the island level and fruitful. The chief product is figs, which are produced in great quantities; and, to prevent their being lost, they are frequently used in making brandy. This spirit, together with wine, which is also made here, is exported to Teneriffe. Various aromatic flowers grow in great abundance; and bees thrive exceedingly well, yielding excellent honey. Ferro is but scantily supplied with water, there being only two or three fountains on the island; so that the cattle, which are numerous, are but ill provided with this indispensable commodity. Ferro was formerly supposed to be the most westerly point of the old world, and hence geographers drew their first meridian of longitude through it. This practice, however, has been abandoned; and almost every nation now makes the first meridian to pass through its own capital, not, we apprehend, with any advantage to science, but rather the reverse. Long. 17. 46. W. Lat. 27. 45. N.

FERRO, or FEROE ISLANDS. See FAROE.

FERROL, a city of Spain, in the province of Gallicia. It is one of the most important of the naval arsenals of the kingdom. Its harbour is deep, capacious, and secure; and the entrance so narrow that not more than one ship at a time can enter. From the mouth being so narrow, it is exposed to the inconvenience of not admitting the entrance or departure of vessels, but with a wind blowing from one particular point. The dock-yard is supplied with ship timber from the Asturias, and with hemp and flax from Aragon; and cordage and sail-cloth are manufactured in the royal workshops. The dry-docks for building and repairing ships in the suburb called Esteyro, are well constructed. At Neda, near the city, a building was lately erected, upon a large scale, for rolling copper into sheets for the bottoms of ships, and for preparing the other works required for coppering ships. The harbour, as well as the city, is very strongly fortified; but some heights are said so to command them as to render the defences of little importance. The population of the city and suburbs amount to about 20,000, most of whom are subsisted by the wages of the arsenal. Long. 7. 41. 14. W. Lat. 43. 29. 30. N.

FERRUGINOUS, any thing partaking of iron, or which contains particles of that metal.

FERTE-LA-MILON, a fortified city of the department of the Aisne, in France, situated on the river Ourcq, containing 480 houses and 2070 inhabitants. It was the birthplace of the celebrated dramatist Racine in 1639.

FERTE SOUS JOUARRE, a town of France, in the department of the Seine and Marne, situated at the junction of the Lesser Morin with the Marne. It contained a university, and has now 434 houses, and 3700 inhabitants. The neighbourhood is celebrated for its cheese.

FERULA, a little wooden pallet or slice, reputed the schoolmaster's sceptre, wherewith he chastises the boys by striking them on the palms of the hands. The word is Latin, and has also been used to denote the prelate's crosier and staff. It is supposed to be formed from the Latin *ferire*, to strike. Under the eastern empire the ferula was the emperor's sceptre, as is seen on different medals. It consists of a long stem or staff, having a flat square head. The use of the ferula is very ancient among the Greeks, who used to call their princes ναρθηκοφοροι, or ferula-bearers.

In the ancient eastern church, *ferula* or *narthex* signified a place separated from the church, in which the penitents or the catechumens of the second order, called *auscultantes*, ακροαματικοι, were kept, as not being allowed to enter the church; and as the persons therein were under penance or discipline, hence the name of the place. *Sub* ferula *erant ecclesiæ*.

FESCENNIA, a city of Etruria, near Falerii, supposed to have occupied the site of the modern Galese, and belonging originally to the Siceli, who were dispossessed by the Pelasgi. Dionysius (i. 21) states that some customs of this latter nation were still observed in his time (29 B. C.). It is chiefly remarkable as having given birth to a species of verse called by the Romans *Versus Fescennini*, and sometimes also *Saturnii*, in reference to the remote antiquity of its origin. As all specimens of this species of poetry have disappeared, we must rest satisfied with the account given of it by Horace. According to him, it was employed at the solemn festivals of their gods, sung in alternate verses by the performers, and was of a gay and cheerful character. The wit was of the rudest kind, and the satire was often so severe, that the laws of the Twelve Tables found it necessary to guard against its abuse. The irregular metre in which these songs, as well as all the poetical attempts of the early Romans, were written, received the name of Saturnian verse. (Hor. *Ep.* ii. 1. 139; Liv. vii. 2; Casaubon *De Sat. Græc. et Rom. Poes.* p. 178; Palmström *De Satir. Orig.* p. 63.)

FESCENNINE VERSES, *Versus Fescennini*, see the preceding article. The word, according to Macrobius, is formed from *fascinum*, a charm, because the people conceived such songs calculated to drive away witches, or prevent the effect of their witchcraft; but its more probable origin is from Fescenni, a city of Etruria, where these verses originated, as above explained.

FESTI DIES, in Roman antiquity, certain days in the year devoted to the honour of the gods. Numa, when he distributed the year into twelve months, divided the same into the *dies festi*, the *dies profesti*, and the *dies intercisi*. The *dies festi* were again divided into days of sacrifices, banquets, games, and feriæ. The *dies profesti* were those days allowed to men for the administration of their affairs, whether of a public or private nature; and they were divided into *fasti*, *comitiales*, &c. The *dies intercisi* were days common both to gods and men, some parts of which were allotted to the service of the one, and some to that of the other.

FESTINO, in *Logic*, the third mood of the second figure of the syllogism, the first proposition of which is an universal negative, the second a particular affirmative, and the third a particular negative; as in the following example:

FES No bad man can be happy;
TI Some rich men are bad men;
NO Therefore, Some rich men are not happy.

FESTOON, in *Architecture* and *Sculpture*, an ornament in the form of a garland of flowers, fruits, and leaves, intermixed or twisted together. Festoons are now chiefly used in friezes and other vacant places which require to be filled up and adorned, and are in imitation of the long clusters of flowers, which the ancients placed on the doors of their temples and houses, executed upon festival occasions.

FESTUS, POMPEIUS SEXTUS, a celebrated grammarian and philologist, who probably flourished towards the close of the fifth century of our era, and who was at all events posterior to Martial, whom he cites under the word *Vespæ*. Festus abridged the great work of Verrius Flaccus, a learned grammarian, *De Verborum Significatione*, omitting obsolete expressions, which were to be treated of in a separate work. This abridgment, which is still extant, is divided into twenty books, in which each word is alphabetically arranged and explained; and it has justly been regarded as one of the most valuable works respecting the Roman language and antiquities which have come down to our times. Indeed, of all the grammarians, Festus is the one who, in the opinion of Julius Scaliger, has rendered the greatest service to the Latin language. The abridgment of Paulus Diaconus is a complete mutilation of the work of Festus. The latter was printed for the first time at Milan, 1471, in small folio, and about the middle of the sixteenth century successively published by Aldus Manutius, Maffei, and, lastly, by the learned Augustin, with notes, Venice, 1560. The Venice edition, which contains the abbreviation of the work of Festus by Paulus Diaconus, and also fragments of Verrius, was reprinted at Paris, 1575, in 8vo, under the superintendence of Joseph Scaliger. About the same time, Fulvio Orsini published the *Fragments* of Festus, as Rallus and Pomponius Lætus had transmitted them to Politian and to J. B. Pius, Rome, 1581, in 8vo; and they were afterwards inserted by Denis Godefroi in the collection of the *Auctores Latinæ Linguæ*, published at Geneva, 1602, in 4to. Lastly, the excellent edition of Dacier, *in usum Delphini*, appeared at Paris in 1681, 4to, and was reprinted in the same form at Amsterdam in 1699, with the notes of Antony Augustin, Fulvio Orsini, and Joseph Scaliger.

FETLOCK, in the manège, a tuft of hair growing behind the pastern joint of many horses; but those of a low size have scarcely any such tuft.

FEUCHTWANG, a bailiwick of the circle of the Rezat, in the kingdom of Bavaria, extending over 115 square miles, and comprehending one city, one town, 101 villages, and 13,000 inhabitants. The chief place is the city of the same name, situated on the river Sulz. It has three churches, 226 houses, and 2150 inhabitants, who find occupation in making muslins, damask table-linen, hats, and leather.

FEUD, in our ancient customs, is used to signify a capital quarrel or enmity, not to be satisfied but with blood; and hence it is usually denominated *deadly feud*. *Feud*, called also *feida*, and *faida*, in the original German signifies *guerran* or war. Lambert writes it *feeth*, and says that it signifies *capitalis inimicitia*, or implacable hatred.

FEUDAL LAW is that system of Gothic jurisprudence which reached its full maturity during the middle ages, and which long continued to regulate the tenure of real property in the principal countries of Europe. The relations of lord and vassal have undergone very essential changes, the knight no longer holds his estate on the condition of military service, and most of the feudal incidents have been gradually superseded as unsuitable to the spirit of modern times; but this law has left many deep traces behind it, and is so closely interwoven with our national institutions, that it could not without great difficulty be entirely disentangled. Where the substance has almost totally vanished, the form is in some instances not very advantageously retained.

Of the word feudal many different etymologies have been proposed. According to Somner, who treads in the steps of Selden and Spelman, feud is a German compound, which consists of *feh*, *feo*, or *feoh*, signifying a salary, stipend, or wages, and of *hade*, *head*, or *hode*, signifying quality, kind, or nature; so that, in its primary acceptation, feudum, or land held in fee, was such as was held in *fee-hode*, by contraction *feud* or *feod*; that is, in a stipendary way, with the acknowledgment of a superior, and a condition of returning some service for it, on the withdrawing of which, the land was revertible to the superior.[1] Sir Martin Wright has remarked that "this etymon not only suggests the most probable account of the word, but gives us the clearest description of the thing itself."[2]

The origin of the feudal system is a question which has been long and much agitated, and different authors have arrived at very different conclusions. "It has puzzled the learned," says Dr Stuart, "to discover the nation of the barbarians which first gave a beginning to fiefs. No inquiry could be more frivolous. In all of them they must have appeared about the same period; and they prevailed in all of them in consequence of the similarity of their situation on their conquests, and in consequence of their being governed by the same customs. It is not therefore to the principle of imitation that their universality is to be ascribed."[3] But the most comprehensive and the most decided opinion is that of Mr Pinkerton, who avers that "the feudal system, about which so much noise is made, is the natural fruit of conquest, and is as old in the world as conquest. A territory is acquired, and the state, or the general, bestows it on the leaders and soldiers, on condition of military service, and of tokens acknowledging gratitude to the donors. It was known in the Greek heroic ages. It was known to Lycurgus, for all the lands of Sparta were held on military tenure. It was known to Romulus, when he regulated Rome. It was known to Augustus, when he gave lands to his veterans, on condition that their sons should, at fifteen years of age, do military service. The reason it did not preponderate and corrupt in Greece and Rome was, that it was stifled by the necessary effects of cities, as above mentioned. In Persia, where there were no cities of any power or privilege, it preponderated and corrupted at an early period. The feudal system, whether in its original democracy, or corrupted into aristocracy, must limit the power of kings; for men who hold their possessions on military service, must of course have arms in their hands: and even in absolute governments the soldiers are free, witness the prætorian bands and armies of imperial Rome, and the Turkish janisaries. By the feudal system every man held arms and freedom in his hands. Montesquieu has begun his account of the feudal system with that of the ancient Germans, given by Tacitus,[4] and prides himself in leaving off where others began. A writer more profound would leave off where Montesquieu begins."[5] This last sentence may be considered as a modest attempt at impressing the reader with an opinion that Pinkerton is a writer more profound than Montesquieu; but, without acquiescing in all his notions, we may at least admit that of the feudal system many authors have taken a view much too narrow and limited. The peculiar relation of lord and vassal, of territorial grants and the tenure of military service, is doubtless to be traced in very remote ages and countries. All the feudal incidents it may often be difficult to detect; but wherever we find portions of land granted to military vassals under the condition, express or implied, of following the standard of their lord, we there find the most essential characters of the feudal system. The order of chivalry may not be found completely engrafted: there may be no denomination equivalent to that of knight, and such incidents as those of relief, aids, and wardships, may be wanting; but instead of a faint analogy, there may still be a very close resemblance between one system and another.

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[1] Somner's Treatise of Gavelkind, p. 106. Lond. 1660, 4to.

[2] Wright's Introduction to the Law of Tenures, p. 4.

[3] Stuart's View of Society in Europe, p. 218. Edinb. 1778, 4to.

[4] Montesquieu de l'Esprit des Lois, liv. xxx. chap. ii. seq.—Dr Stuart commences his researches from the same point. "In the manners of the ancient Germans," he remarks, "I have found the source and spirit of the feudal law." See likewise the elaborate work of Meyer, Esprit, Origine et Progrès des Institutions Judiciaires des principaux Pays de l'Europe, tom. i. p. 4. Haye, 1819-23. 6 tom. 8vo.

[5] Pinkerton's Dissertation on the Origin and Progress of the Scythians or Goths, p. 139. Lond. 1787, 8vo.

"It has been very common," says Mr Hallam, "to seek for the origin of feuds, or at least for analogies to them, in the history of various countries. But, though it is of great importance to trace the similarity of customs in different parts of the world, because it guides us to the discovery of general theorems as to human society, yet we should be on our guard against seeming analogies, which vanish away when they are closely observed. It is easy to find partial resemblances to the feudal system. The relation of patron and client in the Roman republic is not unlike that of lord and vassal, in respect of mutual fidelity; but it was not founded on the tenure of land nor military service. The veteran soldiers, and, in later times, some barbarian allies of the emperors, received lands upon condition of public defence; but they were bound not to an individual lord, but to the state. Such a resemblance to fiefs may be found in the zemindaries of Hindostan, and the timariots of Turkey. The clans of the Highlanders[1] and Irish followed their chieftan into the field; but their tie was that of imagined kindred and respect for birth, not the spontaneous compact of vassalage. Much less can we extend the name of feud, though it is sometimes strangely misapplied, to the polity of Poland and Russia.[2] All the Polish nobles were equal in rights, and independent of each other; all who were less than noble, were in servitude. No government can be more opposite to the long gradations and mutual duties of the feudal system."[3]

Macieiowski, a learned civilian of our own age, discovers manifest vestiges of the feudal system among the ancient inhabitants of Tuscany.[4] To the ancient relation of patron and client, the origin of feudal tenures was traced by Budæus, one of the first lawyers in modern times who applied a very ample store of classical erudition to the illustration of Roman jurisprudence.[5] The same opinion was adopted by Zasius, but it has deservedly been rejected by most of the subsequent commentators; nor is it easy to acquiesce in the speculation of Connanus, who deduces the principles of this law from the fraternities of Soldurii among the ancient Gauls.[6] The assignment of lands by the Roman emperors makes a nearer approach to the proper point. After Augustus had supplanted his rivals, he parcelled certain lands in Italy among his veteran soldiers; and to the classical reader it is well known that, upon this occasion, Virgil was deprived of his little patrimony. The example was followed by other emperors. Alexander Severus allotted to officers and soldiers various lands which had been acquired on the frontiers, and which were to descend to their heirs on the condition of performing military service. This was a plan for securing a permanent guard in the outposts of the empire; and, as Taurellus and Gothofredus have remarked, it bears some resemblance to the feudal system;[7] but Hotman has very clearly pointed out the distinction between these military retainers and the feudal vassals.[8]

Sir Thomas Craig has not overlooked the strong resemblance between the feudal tenures and the Turkish timars.[9] "The Spahyes," says Dr Thomas Smith, "are another great support of the Turkish empire; soldiers who are obliged to serve on horseback by the tenure of the lands (*timars*) and estates they are possest of; these being not only the reward of their sweat and blood, but ties and obligations to further service in the field upon the first summons; each bringing so many horses with him according to the value of what he holds, which is the reason they do not receive an asper of pay out of the Grand Signior's exchequer, and are therefore known by the name of Timar-Spahyes, or *Feudatory*, to distinguish then from other Spahyes who live in the cities, and have not obtained a piece of land."[10] A more recent author represents this military establishment as still unchanged. "These," says Dr Walsh, "are a kind of feudal cavalry, possessing hereditary lands, on the tenure of appearing in the field when called on. If they have no male children, the lands devolve to the commander, who assigns them to others on the same terms, and so the corps is kept up. It consists of sixteen legions; who are perhaps the best mountain horsemen in the world."[11] Major Denham discovered traces of the same system at Bornou in the interior of Africa. "The feudal law," as he informs us, "exists here in full force; and a man unwilling to serve, provides one or more substitutes, according to his means."[12] Here however we have but an inadequate representation of the feudal system. In the centre of India, this system is to be found in a more complicated and perfect form. Of its present character and condition in Rajasthan, some very curious and interesting details have been furnished by Lieut. Col. Tod, who supposes Asia to have been the cradle of feudalism. "The perfection of the system in England," he remarks, "is due to the Normans, who brought it from Scandinavia, whither it was probably conveyed by Odin and the Sacasenæ, or by anterior migrations, from Asia; which would coincide with Richardson's hypothesis, who contends that it was introduced from Tartary. Although speculative reasoning forms no part of my plan, yet when I observe analogy on the subject in the customs of the ancient German tribes, the Franks, or Gothic races, I shall venture to note them. Of one thing there is no doubt—knowledge must have accompanied the tide of migration from the east: and from higher Asia emerged the Asi, the Catti, and the Cimbric Lombard, who spread the system in Scandinavia, Friesland, and Italy."[1] Nor was this system confined to the continental part of Asia: Molina informs us that it prevailed to a great extent in the island of Japan.[2] That the germ of the feudal system first appeared in Asia, is at least highly probable. Its earliest traces have been discovered among the Gothic tribes of Europe. Successive swarms of Goths moved towards the north-western parts of the old world; and when they had subdued many different nations, it may be presumed that they settled the conquered provinces according to some general plan which they had learned in the east. Of the Asiatic tribes it is one great characteristic to adhere, from one century to another, to the customs of their ancestors. This remark is signally verified in the history of the Chinese and Hindus; and it seems applicable to all the other tribes of men who inhabit that quarter of the globe.

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[1] "They are at present," says Dr Smollett, "as free and independent of their chiefs as the law can make them; but the original attachment still remains, and is founded on something prior to the feudal system, about which the writers of this age have made such a pother, as if it was a new discovery, like the Copernican system. Every peculiarity of policy, custom, and even temperament, is affectedly traced to this origin, as if the feudal constitution had not been common to almost all the nations of Europe. For my part, I expect to see the use of trunk-hose and buttered ale ascribed to the influence of the feudal system." (Miscellaneous Works, vol. vi. p. 275.)

[2] With respect to the state of vassalage in those two countries, consult Mr Coxe's Travels into Poland, Russia, Sweden, and Denmark, vol. i. p. 118. 137. vol. ii. p. 93. 110. Lond. 1784, 2 vols. 4to.

[3] Hallam's View of the State of Europe during the Middle Ages, vol. i. p. 200. sec. edit. Lond. 1819, 3 vols. 8vo.

[4] Macieiowski Historia Juris Romani, p. 36. edit. sec. Varsaviæ, 1825, 8vo. "Antiquitus non videntur pertinuisse ad *populum* nisi patricii, moribus Etruscorum id ita serentibus; apud quos minime totus populus libertate gavisus est, sed jus, quod dicitur feudale, ibi valuit."

[5] Budæi Annotationes in Pandectas, p. 359. edit. Paris. 1535, fol.

[6] Connani Commentariorum Juris Civilis tom. i. f. 119. Paris. 1553, 2 tom. fol.—See Cæsar de Bello Gallico, lib. iii. cap. xxii. and Gebaveri Vestigia Juris Germanici antiquissima in C. Cornelii Taciti Germania obvia, p. 148. Gottingæ, 1766, 8vo.

[7] Taurelli de Militiis ex casu, ad Ant. Augustinum Epistola, p. 83. Gothofredus ad Cod. Theodos. lib. vii. tit. xv. p. 305. "Quæ pleraque ad feudorum naturam proxime accedunt," says this most able commentator. Haloander supposes feuds to be mentioned in the Novels under the name of *militiæ*. "Animus erat in finem adjicere Feudorum Consuetudines, quas veteres appellare solebant jura militiarum, et Imp. nominat στρατιας." See his dedication prefixed to *Novellarum Constitutionum Dn. Justiniani Principis, quæ exstant, et ut exstant, Volumen.*" Norembergæ, 1531, fol. This opinion has however been refuted by different writers. "Militiæ enim," says Contius, "fuerunt officia certa ministris magistratuum assignata, quæ pecunia vendi poterant, et ideo in commercio erant, ut fuit officium apparitorum. Apparet ergo multum differre militiam a feudo. Nam militia est jus personæ; feudum in rebus immobilibus et quasi in possessione consistit." (Fornerii et Contii Tractatus de Feudis, p. 84. Leovardiæ, 1694, 8vo.)

[8] Hotomani Disputatio de Feudis, p. 10. Lugduni, 1573, fol. [9] Cragii Jus Feudale, p. 27. edit. Baillie. Edinb. 1732, fol.

[10] Smith's Remarks upon the Manners, Religion, and Government of the Turks, p. 133. Lond. 1678, 8vo.

[11] Walsh's Narrative of a Journey from Constantinople to England, p. 186. Lond. 1828, 8vo.

[12] Denham's Narrative of Travels and Discoveries in Northern and Central Africa, p. 150. Lond. 1826, 4to.

Of the early progress of the feudal system, so able a delineation has been given by Dr Stuart, that we are here tempted to introduce a long extract from his work. Having quoted a passage from Tacitus,[3] he proceeds with the subsequent commentary. "This passage abounds in instruction the most important. It informs us that the German had no private property in land, and that it was his tribe which allowed him annually for his support a proportion of territory; that the property of the land was invested in the tribe, and that the lands dealt out to individuals returned to the public, after they had reaped the fruits of them; that, to be entitled to a partition of land from his nation was the distinction of a citizen; and that, in consequence of this partition, he became bound to attend to its defence, and to its glory. With these ideas, and with this practice, the Germans made conquests. In conformity therefore with their ancient manners, when a settlement was made in a province of the empire, the property of the land belonged to the victorious nation, and the brave laid claim to their possessions. A tract of ground was marked out for the sovereign; and, to the inferior orders of men, divisions corresponding to their importance were allotted. But while, in their original seats, such partitions were annual, it was expedient that they should now be invested in the possessor. A more enlarged idea of property had been gradually unfolding itself; and though it was convenient to, and suited the views of a narrow community, to take back its land, the measure was not practicable in an extensive society. Nations were no longer to shift their habitations. The boundaries of particular states were to be respected. The tribe ceasing to wander, the individual was also to be stationary. The lot or partition now received by him, was to continue in his possession, and to be an object of his industry. He was to take root, if I may so speak, in a particular spot. He was to bestow on it his affection; it was to feed and to enrich him with its produce. His family was to feel an interest in his estate; his sons were to succeed him. Heirs were to fail in the blood of the proprietor. It affected him, that the crown or a stranger should possess the subject of his toils and attentions. The powers of sale and donation came to be understood. The right of holding a landed territory with no limitation, and of disposing of it at pleasure, was known and prevailed.... When we mount up to the origin of customs, we are to be struck with their simplicity. The lot or partition to the sovereign was to constitute his domains. It was to support his splendour, to defray the expenses of government, and to maintain his household. The lot or partition to the individual was to give rise to allodiality. It was the land which was free, in contradistinction to tenure; and, being still the mark of a citizen, it subjected him as in Germany, to the general obligation of taking arms in defence of the community.[4] But the domains of the sovereign, and the lands of lot or partition to the people, could not exhaust all the territory of a conquest. They were principal and natural objects of attention; yet, after their appointment, there were much extensive property, and many fair possessions. The ancient maxims of the people did not allow them to seize these by a precarious occupation. Men who had connected the property of land with the tribe, and not with the individual, could not conceive any title in consequence of which they might arrogate possessions to humour their fancy, or to flatter their pride. Their ancient notions continued their operation: the community was concerned with what no man could claim. The lands accordingly which were assigned neither to the sovereign nor to the people, which formed not the domains of the former, nor the partitions of the latter, were the lands of the state or the fisc."[5]

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[1] Tod's Annals and Antiquities of Rajast'han, or the Central and Western Rajpoot States of India, vol. i. p. 132. Lond. 1829–32, 2 vols. 4to.

[2] "Illud obiter dixerim, apud Japonenses nil videri esse frequentius quam feuda. Cum enim bellis perpetuo in ea ingenti insula principes inter se contendant, antiquo inter eos more, quæ unusquisque bello obtinet, continuo dividit inter suos duces, et alios quos diligit, cum onere sibi serviendi in bello, et alia onera præstandi; mutatque dominos de uno loco in alium, auferendo ab eis quæ possidebant, et alia eis largiendo. Majores autem dinastæ sub supremo aliquo principe ita constituti, divisa habent loca, quibus dominantur, in alios sibi inferiores, cum eisdem oneribus sibi inserviendi in bello et præstandi alia realia onera, et illi in alios, quousque devenitur ad infimos *tonos*, quos ipsi vocant, qui similiter dominantur unusquisque in suo oppido, et simili fere lege, ut vassalli ipsum comitentur in bellum, et servitia alia realia præstent. Mores tamen et usus feudorum non iidem, sed diversi in aliquibus sunt apud ipsos ab iis qui in Germania, Gallia, et Italia vigent." (Molina de Justitia et Jure, tom. ii. col. 1062. edit. Mogunt. 1659, 6 tom. fol.)

[3] Tacitus de Moribus Germanorum, cap. xxvi.

[4] "The allodial lands," as Dr Stuart remarks, "were enjoyed in full property, and are therefore opposed to feudal or beneficiary possessions, which were received with limitations, and under the burden of military service to the grantors." The word *al-od* is supposed to be equivalent to *all-hood*, and therefore to indicate completeness of possession. It is synonymous with *udal*, which is employed to denote the right of such lands in Orkney and Zetland; "whereby," as Lord Stair has stated, "without any infeftment, investiture, or other right or writ, they enjoy lands and hereditaments." (Institutions of the Law of Scotland, b. ii. tit. ii. § 11.) See likewise Lord Bankton's Institute of the Laws of Scotland, vol. i. p. 541. This word is evidently borrowed from the ancient Norwegian language. In the Islandic language, *ódal* signifies allodial property, but it also signifies *res derelicta*. (Haldorsonii Lexicon Islandicum, vol. ii. p. 121.) It is not therefore improbable that the term was originally applied to lands which, having been found deserted, were occupied without form or ceremony.

[5] Stuart's View of Society in Europe, p. 24.—It is not the object of this article to attempt a developement of the feudal system, but merely a faint outline of the history of the feudal law. Besides the different works which we here have occasion to quote, particularly those of Stuart and Hallam, we may refer the English reader to Dr Robertson's View of Society in Europe, prefixed to his History of Charles V.

Du Moulin has traced the origin of the feudal law to the Franks, by whom he supposes it to have been introduced into Gaul.[1] Grótius and other writers have, with greater probability, represented it as having been widely diffused at an early period.[2] Lombardy has frequently been regarded as the place of its origin, because to that country we are indebted for the ancient digest of this consuetudinary law.[3] The *Feudorum Consuetudines* are said to have been compiled by Gerardus Niger, who is likewise called Capagistus, and by Obertus de Orto or Horto, who were both lawyers and consuls of Milan.[4] They lived in the reign of Frederick the First, surnamed Barbarossa, which commenced in 1152, and terminated in 1190. Whatever share they might have in preparing the materials, it may perhaps be suspected that they did not digest the work in its present form. Their opinions are on some occasions placed in opposition to each other, and are quoted as if from distinct works. Thus in lib. ii. tit. li. § 3. "Similiter si quis investitus fuerit de feudo, ita ut ad fœminas transiret, et duas filias tantum reliquerit, quarum una filium habeat, et altera filiam; utrum post mortem illarum masculus tantum feudum habere debeat? Secundum Gerardum, masculus tantum: Obertus contra." And in § 6 of the same title: "Similiter feudum lege commissoria datum non valet, id est, si ad certum tempus pecunia non solvatur creditori, ut habeat in feudum. Gerardus. Et secundum Obertum, valet." On other occasions, both names are subjoined: "Gerardus et Obertus." It might indeed be conjectured that the work was arranged by their joint labour; and that when any difference of opinion occurred, they took care to state it in this formal manner. Du Moulin supposes Obertus to have been the sole compiler. We are assured by Odofredus, a commentator on the Code, who lived about the year 1250, that Hugolinus, otherwise called Hugo a Porta Ravennate, who died in the year 1168, added the feudal law to the ninth collation of the Novels, and that it was received as a tenth collation.[5] Some writers consider the statement as a mere device, intended to enhance the authority of this branch of jurisprudence. The feudal law is commonly subjoined to the *Corpus Juris Civilis*, of which many of the older civilians regarded it as a component part. "The last tome of the civile law," says Sir Thomas Ridley, "is the Feudes, that is, the books of customes and services that the subject or vassall doth to his prince or lord, for such lands or fees as he holdeth of him."[6] In the common editions, the *Feudorum Consuetudines* are divided into two books; but the edition of Cujacius, Coloniæ, 1588, 8vo, exhibits a new arrangement, with a series of five books. The first book he ascribes to Gerardus, the second and third to Obertus; the fourth is taken from several ancient authors, and the fifth consists of imperial constitutions relative to matters of feudal cognizance. To the common editions in two books, are likewise appended constitutions of several emperors; and two of them, issued by Henry the Seventh, are described by the term *Extravagantes;* a term which is also used in the canon law, to denote documents which wander beyond the limits of a particular collection.[7] The work itself is partly composed of such constitutions; and the entire collection closes with an instrument relative to the peace of Constance, *De Pace Constantiæ*, concluded, on the one part, between the emperor Frederick the First, his son Henry king of the Romans, and certain nobles of Germany, and, on the other, various cities of Lombardy, the march of Ancona, and Romagna.

These books of the feudal law are evidently written by individuals familiar with the doctrines and the phraseology of the civil law; and the new system of jurisprudence may be considered as a scion from the old. The composition necessarily partakes of the general barbarism of the age to which it belongs, nor are the materials reduced to a systematic or lucid form.[8] Some of the more classical civilians have therefore treated this law of Lombardy with the utmost contempt.[9] As to the authority which properly belongs to it, the feudalists have entered into much discussion, and have maintained various opinions. Some of the early writers represent it as having been sanctioned by different emperors, particularly by the first three Fredericks, but others consider this sanction as more than doubtful. Craig is induced to suppose that the feudal law must have derived its authority from some imperial rescripts, although they have not descended to our time; for he cannot conceive that the emperors would otherwise have permitted it to be taught in the schools, and observed in the judicatories. Du Moulin, on the other hand, considers the private part of the compilation as unwritten law, "jus non scriptum," adopted at Milan, and the remainder, the constitutions interspersed, as written law, "jus scriptum," retaining its force within the limits of the empire.[10] This appears to be a very sound opinion; nor do we think it necessary to mention the various suggestions and speculations of other writers. In many different countries, this compilation has been received and partly adopted as consuetudinary law, and in all those countries has been modified by tacit usage, or by express enactments, nor has it any other authority except such as it has thus obtained. The Lombardic body of law is described as "Feudorum Consuetudines," and "Jus Feudale commune;" the first title denoting that it is consuetudinary or unwritten law, and the second, that it has obtained more or less authority wherever the feudal law has been adopted.

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[1] Molinæi Commentarii in Parisienses Consuetudines, p. 10. edit. Genev. 1613, fol.—The same opinion is adopted by many other writers, and, among the rest, by Hervé in his Théorie des Matieres Féodales et Censuelles, tom. i. p. 2.

[2] Grotius de Jure Belli ac Pacis, lib. ii. cap. vii. § 21. See the same illustrious writer's Historia Gotthorum, Vandalorum, et Langobardorum, prol. p. 64. Amst. 1655, 8vo.

[3] Panciroli Thesaurus variarum Lectionum utriusque Juris, p. 130. Venetiis, 1611, fol. Giphanii Antinomiæ Juris Feudalis, p. 29. Francofurti, 1606, 4to. "Manet igitur verum," says Giphanius, "feuda, quoad originem, ad clientelas Romanorum, vel ad homines Romanorum referre posse. Deinde, feuda sunt ex jure Longobardorum, non si spectemus originem, sed si respiciamus ad rerum distinctiones, ordinationes, constitutiones, statuta, quæ ex moribus et quotidiana observatione Longobardorum fluxerunt."

[4] Dieck's Literärgeschichte des Longobardischen Lehenrechts. Halle, 1828, 8vo. Laspeyres ueber die Entstehung und älteste Bearbeitung der Libri Feudorum. Berlin, 1830, 8vo.

[5] B. G. Struvii Historia Juris, p. 721. Jenæ, 1718, 4to.

[6] Ridley's View of the Civile and Ecclesiasticall Law, p. 68. sec. edit. Oxford, 1634, 4to.

[7] See F. A. Biener's Geschichte der Novellen Justinian's, S. 277. Berlin, 1824, 8vo.

[8] "Stilus forensis est, qualis jurisconsultorum ejus temporis esse potuit: scripti enim sunt seculo inerudito, neque fieri potuit quin aliquod ejus seculi vitium contraxerint. Verba ipsa Latina, nisi si quæ sint fori propria. Phrasis, sive, ut grammatici loquuntur, constructio Longobardica est, ut facile quivis sine interprete sensum percipere potest. Tumultuarie sane sunt conscripti, ex adversariis sive schedis Gerardi et Oberti relictis, ab alio puto quam ipsis collectis. Obertus enim et Gerardus, prout quæque facti species occurrerat, consulti quid de eo sentirent, scripto declararunt. Hæc eorum adversaria, post eorum excessum, aliquis juris feudorum studiosus in libros redegit, sine delectu, sine methodo, quod non est negandum: ita tamen eorum responsa celebrata sunt, et in honore habita, ut pro jure certissimo a posteris adhuc sint usurpata." (Cragii Jus Feudale, p. 36.)

[9] "Feuda postremo," says Taurellus, "quæ non minus barbaro quam inepto, et sibi parum constanti, ac vix meo judicio legi digno volumine continentur." (De Militiis ex casu, ad Ant. Augustinum Epistola, p. 81.) See likewise Gravinæ Origines Juris Civilis, p. 103. edit. Mascovii.

[10] Molinæi Commentarii in Parisienses Consuetudines, p. 24.—See likewise Duck de Usu et Authoritate Juris Civilis, f. 35. b. Bitschii Commentarius in Consuetudines Feudorum, p. 14. G. A. Struvii Syntagma Juris Feudalis, p. 30.

The substance of these books was digested into a new form by Antonius Minuccius a Prato Veteri, a professor in the university of Bologna, who was born about the year 1380;[1] and his labours are said to have received the sanction of the emperor Sigismund, as they certainly did that of Frederick the Third.[2] Haloander had originally intended to subjoin it to his edition of the Novels; but it was not till after a long interval that the work was first published by Schilter. Another digest of the same materials was afterwards undertaken by Bartholomæus Baraterius or de Barateriis, who was a native of Piacenza, and was successively a professor at Pavia and Ferrara. Having completed his work in 1442, he dedicated it to the duke of Milan. It was first printed at Paris in the year 1612.[3] Neither of these works seems to have obtained any permanent footing, even in the universities of Italy. The books of the feudal law were exhibited in a German dress by Dr Lorenz Weidmann, who likewise introduced some changes of arrangement. His work, *Die Lehenrecht verdeutscht*, was printed by Schoiffer of Mainz in the year 1530.

The principles of the feudal law had soon begun to be taught in the universities. The text was illustrated by many glosses and commentaries; and many summaries and treatises have from time to time been added. The principal feudalists who preceded his own time, are thus enumerated by Dr Duck: "Horum librorum authoritatem augent egregii illi jurisconsulti qui ad eos glossas, commentarios, et tractatus scripserint. Glossas in Feuda scripserunt Bulgarus, Pyleus, Ugolinus, Vicentius, Jac. Goffredus, aliique; sed Jac. Columbinus eorum ultimus omnes superavit, et post eum, ait Jason, nemo glossas in Feuda scribere tentavit.[4] Alii summas et tractatus de Feudis composuerunt, Odofredus, Jac. de Arena, Hostiensis, Jac. Ardizoni, Zasius, Rebuffus, Hannetonius, Henr. Rosenthall, aliique, qui omnem Feudorum scientiam amplissime tradiderunt. Commentarios in Feuda scripserunt Jac. de Belvisio, Andr. de Iserma, Baldus, Jac. Alvarottus, Math. de Afflictis, Fr. Curtius, Jac. Cujacius, aliique, in quibus eminet Cujacii elegantia et literarum splendor, authoritas et judicium Jac. de Belvisio et Baldi, quorum ille octies se legisse libros Feudorum Papiæ testatur, Baldus vero commentarios suos scripsit postquam jus civile per quadraginta septem annos professus insignem famam acquisiverat. Et inter hos omnes e glossographis Jacobo Columbino, e summistis Jacobo Ardizoni, e commentariis Jacobo de Belvisio primus locus ab omnibus conceditur."[5] To this enumeration some names ought perhaps to have been added, particularly those of Hotman and Vulteius. Of the more recent commentaries on the text, the most copious is that of Caspar Bitsch, professor of law in the university of Strasburg.[6] Among the systematic treatises which have appeared since the publication of Duck's very useful work, it may be proper to mention the elder Struve's *Syntagma Juris Feudalis*, which contains much information in a form not very elegant or attractive.[7] Many elementary works, such as those of Schilter, Stryk, and G. L. Böhmer, and an immense number of detached dissertations, have from time to time been published in Germany, where every province of jurisprudence is most laboriously cultivated. Of separate tracts on the feudal law, an ample collection was published in Jenichen.[8] Various writers treat of this law as it has been adopted and modified in different countries. Thus the feudal law, as applied in Scotland, has been illustrated with much learning and ability by Sir Thomas Craig, one of the greatest lawyers whom his country has produced. One of the earliest books on the law of England is Thomas Littleton's treatise on tenures; and the feudal law of that country was afterwards discussed by Sir Henry Spelman, Sir Martin Wright, Sir Jeffrey Gilbert, and various other writers.

In France the feudal law was embodied in the *loi coutumier* of different provinces; and many curious reliques of jurisprudence have thus been preserved. The most interesting of these are perhaps the *Coustumes de Beauvoisis*, digested by Philippes de Beaumanoir.[9] Montesquieu has described it as an admirable work,[10] and has quoted it upon many different occasions. "This treatise of Beaumanoir," says Mr Barrington, "is so systematical and complete, and throws so much light upon our ancient common law, that it cannot be too much recommended to the perusal of the English antiquary, historian, or lawyer. He kept the courts of the Comte de Clermont, and gives an account of the customary laws of Beauvoisis (which is a district about forty miles to the northward of Paris) as they prevailed in the year 1283. He is consequently a more ancient writer than Littleton, and, to speak with all due reverence of this father of our law, perhaps a better writer. It need hardly be said that the customs of the two countries were at this time very similar, especially of the more northern parts of France: if we wanted other proof, the commentators on the oldest French law books cite Littleton as illustrating their customs."[1] Of the customary laws of France the other collections are very numerous.[2] Nor must we here neglect to particularize a very curious relique of early jurisprudence, the *Assises de Jerusalem*, which are decidedly of a French origin. After the conquest of the holy city in the year 1099, the barons who led the crusade elected Godefroy de Bouillon king of Jerusalem; and it was one of the new sovereign's first cares to form a body of laws for the government of his subjects. By the counsel of the patriarch, and of his princes and barons, "et des plus sages homes qu'il pooit avoir," he appointed wise men to make enquiry at persons from different countries as to the particular usages of those countries. Having received the desired information in writing, he again assembled his principal adherents; and having laid this document before them, and caused it to be read, he afterwards, with their counsel and concurrence, selected what to him seemed good, "et en fit assises et usages que l'on deust tenir et maintenir, et user au royaume de Jerusalem, par lesquels il, ses gens, et son peuble, et toutes autres manieres des gens alans, et venans, et demorans, fussent governés et menés à droit et à raison el dit royaume." They were called *Assises* from the circumstance of their having thus been confirmed in an assembly of the chief persons of the state. They were afterwards modified and enlarged by this king and his successors; and about the year 1250 were arranged by Jean d'Ibelin, Comte de Japhe et d'Ascalon, Seigneur de Rames et de Baruth. Having been adopted in the kingdom of Cyprus, they were revised in the year 1369 by sixteen individuals nominated in an assembly of the estates of that kingdom. They had been translated into Greek for the benefit of those subjects who did not understand the original language; and of this version some portions have been preserved in the Royal Library at Paris. After Cyprus had fallen under the dominion of the Venetians,[3] the book was translated into the Italian language.[4] It is generally admitted that the laws thus adopted in the kingdoms of Jerusalem and Cyprus, were in a great measure derived from the customs and usages of the kingdom of France.

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[1] Pancirolus de claris Legum Interpretibus, p. 198. Savigny's Geschichte des Römischen Rechts, Bd. vi. S. 255. Osservazioni e Dissertazioni varie sopra il Diritto Feudale, concernenti l'Istoria e le Opinioni di Antonio da Pratovecchio, celebre Giureconsulto del Secolo xv. e Riformatore dei Libri de' Feudi. Livorno, 1764, 4to. This elaborate volume, which appeared without the name of the author, was written by Migliorotto Maccioni, a professor in the university of Pisa.

[2] Laspeyres über die Entstehung und älteste Bearbeitung der Libri Feudorum, S. 126. Berlin, 1830, 8vo. This is a work of much critical research, and the author, who is now a professor in the university of Halle, belongs to the school of Savigny.

[3] The works of Minuccius and Baraterius are subjoined to Schilter's Codex Juris Feudalis Alemanniei. Argentorati, 1695, 4to.

[4] See Savigny's Geschichte des Römischen Rechts im Mittelalter, Bd. v. S. 82. Heidelberg, 1815–31, 6 Bde. 8vo.

[5] Duck de Usu et Authoritate Juris Civilis, f. 38. edit. Lond. 1653, 8vo. A similar account is given by Pancirolus, Thesaurus variarum Lectionum utriusque Juris, p. 131. Venetiis, 1611, fol. See likewise Rittershusii Partitiones Juris Feudalis, p. 15. edit. Argentorat. 1659, 8vo.

[6] Caspari Bitschii Commentarius in Consuetudines Feudorum. Argentorati, 1673, 4to.

[7] Geo. Ad. Struvii Syntagma Juris Feudalis. Francofurti ad Moenum, 1703, 4to. This is the eighth edition.

[8] Thesaurus Juris Feudalis, continens optuma atque selectissima Opuscula, quibus Jus Feudale explicatur. Francof. ad Moen. 1750–4, 3 tom. 4to.

[9] Coustumes de Beauvoisis, par Messire Philippes de Beaumanoir, Bailly de Clermont en Beauvoisis, Assises et bons Usages du Royaume de Jerusalem, par Messire Jean d'Ibelin, Comte de Japhe et d'Ascalon, S. de Rames et de Baruth, et autres anciennes Coutumes; le tout tiré des manuscrits, avec des notes et observations, et un glossaire pour l'intelligence des termes de nos anciens autheurs, par Gaspard Thaumas de la Thaumassiere, Ecuyer, S. de Puy-ferrand, Bailly du Marquisat de Château-neuf-sur-Cher, Avocat en Parlement. Bourges, 1690, fol.—Of the *Assises de Jerusalem*, a new and complete edition, in three volumes quarto, was in 1830 announced by Cotta of Stuttgard. The editors are E. H. Kausler and J. C. Bluntschli, who promise a very careful revisal of the text, with copious and various illustrations; and, for the satisfaction of many readers, we may add that they write, not in German, but in Latin. Of the second part, the *Assise de la Court des Borgés*, the original has not yet been printed. Some extracts, relative to maritime law, may be found in Pardessus, *Collection de Lois Maritimes antérieures au XVIII*e *Siècle*, tom. i. p. 275. Paris, 1828, 4to.

[10] Montesquieu de l'Esprit des Lois, liv. xxvi. chap. xv.

The feudal system seems to have arrived at maturity during the reign and in the dominions of Charlemagne and his immediate successors. The reliques of their legislation are to be found in the *Capitularia Regum Francorum*, of which we have given a separate account. As the empire of Charlemagne not only included France and Germany, but likewise a great portion of Italy, and some portion of Spain, a certain uniformity of laws and usages was naturally promoted by this political union. "Feudal tenures," it is stated by Mr Hallam, "were so general in the kingdom of Aragon, that I reckon it among the monarchies which were founded upon that basis. Charlemagne's empire, it must be remembered, extended as far as the Ebro. But in Castille and Portugal they were very rare, and certainly could produce no political effect. Benefices for life were sometimes granted in the kingdoms of Denmark[5] and Bohemia. Neither of these, however, nor Sweden,[6] nor Hungary, comes under the description of countries influenced by the feudal system. That system, however, after all these limitations, was so extensively diffused, that it might produce confusion, as well as prolixity, to pursue the collateral branches of its history in all the countries where it prevailed."[7] The prevalence of the feudal law in Lombardy has already been mentioned; and it sooner or later extended its influence to almost every corner of Italy, including the islands as well as the continental states.[8] In England and Scotland it struck a very deep and vigorous root. Its progress in the former country seems to be correctly stated by Blackstone. "This feudal polity," he remarks, "which was thus by degrees established over all the continent of Europe, seems not to have been received in this part of our island, at least not universally, and as a part of the national constitution, till the reign of William the Norman. Not but that it is reasonable to believe, from abundant traces in our history and laws, that even in the times of the Saxons, who were a swarm from what Sir William Temple calls the same northern hive, something similar to this was in use; yet not so exclusively, nor attended with all the rigour that was afterwards imported by the Normans. For the Saxons were firmly settled in this island, at least as early as the year 600; and it was not till two centuries after, that feuds arrived to their full vigour and maturity, even on the continent of Europe."[9] Craig supposes the feudal law to have been established in Scotland before it was established in England;[10] but this is an opinion which apparently must continue to rest on conjecture, and not on historical evidence. (x.)

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[1] Barrington's Observations on the more ancient Statutes, p. 439.

[2] See Dupin's edition of Camus's Lettres sur la Profession d'Avocat, tom. ii. p. 190.

[3] See Johann Paul Reinhards vollständige Geschichte des Königreichs Cypern. Erlangen und Leipzig, 1766–8, 2 Bde. 4to.

[4] Le Assise et bone Vsanze del Reame de Hyervsalem. Venetia, 1535, fol. The volume concludes with the following colophon: "A laude & honor del Omnipotente Iddio, finisce il presente libro, qual è de le Assise & bone Vsanze del Reame de Hierusalem, stampato in Venetia, regnante l'inclito Meser Andrea Gritti, Doxe di Venetia, nelli anni de la Natiuita del Signor nostro MDXXXV. del mese di Marzo, in la stamparia di Aurelio Pincio Venetiano." The name of the translator is Florio Bustron. This translation contains both the laws which relate to *L'alta Corte* and those which relate to *La Corte de li Borgesi*. Both parts may be found in the collection of Canciani, *Barbarorum Leges antiquæ*, vol. ii. p. 479. vol. v. p. 107. Venetiis, 1781–92, 5 tom. fol.

[5] See Dansk Lehns Ret af Peder Kofod Ancher. Kiöbenhavn, 1777, 8vo.

[6] Stiernhöök de Jure Sueonum et Gothorum vetusto, p. 276. Holmiæ, 1682, 4to.

[7] Hallam's View of the Middle Ages, vol. i. p. 201.

[8] The Sicilians, says Mr Brydone, "still boast that they retain more of the feudal government than any nation in Europe. The shadow indeed remains, but the substance is gone long ago." (Tour through Sicily and Malta, vol. ii. p. 225. Lond. 1773, 2 vols. 8vo.)

[9] Blackstone's Commentaries on the Laws of England, vol. ii. p. 48. See likewise Dr Sullivan's Historical Treatise on the Feudal Law, and the Constitution and Laws of England, p. 18. Lond. 1772, 4to.

[10] Cragii Jus Feudale, p. 47. Brussii Principia Juris Feudalis, p. 5. Edinb. 1713, 8vo. See Dr Stuart's Observations concerning the Public Law and the Constitutional History of Scotland, p. 7. Edinb. 1779, 8vo. Lord Kames, whose speculations often rest upon a very insecure foundation, is pleased to express himself in the following terms: "I entertain some doubts whether the feudal law was introduced into Scotland so early as in the reign of Malcolm II. What to me brought this thing first under suspicion, is a fact that can be made extremely evident. When one dives into the antiquities of Scotland and England, it will appear that we borrowed all our laws and customs from the English. No sooner is a statute enacted in England, but, upon the first opportunity, it is introduced into Scotland; so that our oldest statutes are mere copies of theirs. Let the Magna Charta be put into the hands of any Scotsman, without giving its history, and he will have no doubt that he is reading a collection of Scots statutes or regulations. Now it is a point settled among the best English antiquaries, that the feudal law was introduced into England by William the Conqueror. I need not spend time upon this topick, after what is said by the accurate Spelman, and by our countryman Craig. Joining these two things together, a strong presumption arises, that the feudal law made its progress from England to this country, as all the English statutes, making improvements and alterations upon it, certainly did. But this presumption receives additional force,

FEVERSHAM, a town of the county of Kent, in the hundred of that name, within the lathe of Scray, and forty-eight miles from London. It is a very ancient town, and from several of our early monarchs obtained various charters and privileges, especially as regards the judgment and punishment of offences committed within its own jurisdiction. Although it sends no members to parliament, it has, besides a mayor, jurats, and commoners, a steward, two recorders, and a chamberlain, and the corporation are trustees for various charitable institutions. Feversham is of comparatively less importance than formerly, as may be seen by its curious church, its town-hall, and some other buildings of great antiquity. It is now chiefly of consideration from the great manufactory of gunpowder carried on by the government, which gives occupation to many families; whilst others are employed in the fishery for oysters for the supply of London. Near to it the river Swale enters the sea, and the quarantine rendezvous of Sandgate Creek is so near as to form a communication with the ships under detention. There are good markets on Wednesdays and Saturdays. The great road from London to Canterbury avoids the town, though it passes within less than a mile of it. The population in 1801 amounted to 3488, in 1811 to 3872, in 1821 to 4208, and in 1831 to 4429.

FEVRE, Tannegui Le, in Latin *Tanaquillus Faber*, one of the most able scholars of his age, was born at Caen, in Normandy, in the year 1615. His father (who, according to Segrais, was the son of a grave-digger in the parish of St Jean de Caen), having dissipated his means, an uncle of the young Lefevre, a learned ecclesiastic, took charge of his education, and finding that he had a good ear and a fine voice, taught him music, by which means he was ere long in a condition to execute the most difficult pieces with the book open before him. He was twelve years of age when he commenced Latin, and his progress was extremely rapid. But the severity of his uncle discouraged him, and his father could only induce him to continue his studies by giving him another preceptor. The latter, however, did not understand Greek; but Lefevre learned it alone, without any other assistance than a grammar, and some books which he read before he was in a condition fully to comprehend their meaning. He was then sent to study humanity and philosophy at the college of La Flêche, one of the most celebrated which the Jesuits possessed in France. His masters made useless efforts to detain him amongst them; and his father and uncle equally failed in persuading him to take orders. After remaining several years in Normandy, he proceeded to Paris, where he soon made himself known, and gained the friendship of several persons of distinction. M. Desnoyers, one of these friends, presented him to Cardinal Richelieu, who appointed him inspector of the press of the Louvre, with a salary of two thousand livres. But, after the cardinal's death, the pension of Lefevre became ill paid, and he was even obliged to sell his library, in order to procure the means of subsistence. Some time afterwards, the Marquis of Francières carried Lefevre with him to Langres; but having in that city acquired a taste for the reformed doctrines, the latter took leave of his noble friend, and retired to Preuilly in Touraine, where he publicly made profession of Calvinism. He was immediately offered a chair in the academy of Saumur, which he accepted in preference to the professorship of Greek at Nimeguen, to which he was about the same time appointed. But he had afterwards some disputes with the consistory of Saumur, in consequence of having unguardedly attempted to excuse the libertinism of Sappho; and as the annoyance which this misunderstanding occasioned had determined him to quit Touraine, he was preparing to set out for Heidelberg, where the elector palatine had offered him considerable advantages, when he died of a fever produced by excess of labour, on the 12th of September 1672. By his marriage with Marie Olivier, Lefevre left three children; a son, named Tannegui after his father, who, after having for thirty years discharged the pastoral functions in Holland and in England, returned into the bosom of the Catholic church, and died at Saumur in 1717; and two daughters, one married to Paul Bauldry, and the other the celebrated Madame Dacier. Lefevre wrote better in Latin than in French; but if his productions are deficient in elegance, they have at least the merit of fidelity, and are accompanied with very learned notes. His productions consist of, 1. Editions of several works of Lucian, with a Latin version and notes; Longinus's *Treatise on the Sublime*, with the Latin and notes, Saumur, 1663; the Fables of Phædrus; Lucretius; the *Histories* of Ælian; Eutropius, Justin, Terence, and Horace; the *Library* of Apollodorus; Virgil; the *Panegyric of Trajan* by Pliny the younger; Dionysius of Alexandria, Anacreon, and Sappho: 2. French Translations of the *Festinus* of Xenophon, the *First Alcibiades* of Plato, the *Treatise on Superstition* by Plutarch, and the *Life of Aristippus* by Diogenes Laertius: 3. The translation into Latin verse of the *Fables* of Lockman, Saumur, 1673, in 12mo, a translation which was executed during his last illness: 4. *Diatribe Fl. Josephi de Jesu Christo testimonium suppositum esse*, Saumur, 1655, in 8vo; 5. *Epistolarum partes ii.* ibid. 1659, 1665, in two vols. 4to: 6. *Les Vies des Poètes Grees*, 1665, in 12mo, to which is subjoined *Le Mariage de Belfegor*, translated from the Italian of Machiavelli, and the Life of Theseus, translated from the Greek of Plutarch: 7. *Méthode pour commencer les Humanités Grecques et Latines*, in the *Mémoires de Littérature* of Sallengre, tom. ii. pt. 2, p. 62: 8. *Notes* on the *Scaligeriania Prima*. (See *Mémoires pour servir à la Vie de Tannegui Lefevre*, by Fr. Graverol, 1686; and the *Mémoires de Nicéron*.)

FEZ, an extensive country of Africa, and at one time the most flourishing kingdom in the northern part of that continent. It now, however, forms one of the four provinces or kingdoms into which the empire of Morocco is divided. It is bounded on the north by the Straits of Gibraltar and the Mediterranean Sea, on the east by Algiers, on the south by Morocco, and on the west by the Atlantic Ocean. Besides being bordered in one part by the chain of the Greater Atlas, a smaller one called the Lesser Atlas runs across it, extending from the Great Atlas to the sea near Tetuan, a considerable city situated on the Straits of Gibraltar. It is likewise traversed in various directions by other ranges of mountains, some of which are lofty, rugged, and barren, whilst others are adapted for pasture. The intervening plains and valleys, however, which are frequently many miles in extent, being finely watered, are in the highest degree fertile, and capable of producing all the luxuries of the eastern and western worlds. The soil of the interior is a rich black loam, which, although but very slightly cultivated, is remarkably prolific. The mountainous parts also might, by suitable cultivation, be made to produce abundantly those fruits which thrive best in the hilly regions of warm climates; but they are for the most part utterly neglected. The Moors know little of agriculture; and, besides, they only cultivate in proportion to their im-

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when it is considered, that if we had the feudal law before it came into England, it must have been taken from some other people than the Normans, with whom we had no commerce." (Essays upon several Subjects concerning British Antiquities, p. 4. Edinb. 1747, 8vo.) Of such random assertions as these, it would be superfluous to attempt a formal refutation.

mediate wants; so that a considerable portion of the country is allowed to lie untilled. The principal rivers are the Mulluwia or Mulvia, which separates Fez from Algiers; the Morbeya or Ommirabee, which separates Fez from the province of Tedla; and the Seboo, which waters the interior of the country. Fez is estimated to contain about 89,000 square miles in superficial extent, and its territorial divisions are as follows:

Districts.	Chief Towns.
Erreef or El Rif.	
El Gharb.	Tetuan, Tangier, Arzilla.
Beni Hassan.	Sallee, Rabat.
Temsena.	Dar el Beyda.
Shawiya or Shavoya.	
District of Fez or Fas.	Fez, Mekennes.
Tedla.	

The government, statistics, and commerce of this region in every respect resemble those of Morocco, of which it is indeed a part, and they will accordingly be described under that article.

FEZ, or FAS, the capital of the above kingdom, was built in 786, by a prince of the name of Edris, and having soon risen to be a city of the first magnitude, became the capital of the western Mahommedan states. In the twelfth century it is said to have contained seven hundred temples and mosques, a number of which were erected upon a magnificent scale, and adorned with a profusion of marble pillars. It was at one time held in the highest veneration; and when the road to Mecca was shut up, in the fourth century of the Hegira, pilgrimages to Fez were performed by the western Moslemins, who considered it as a place nearly equally sacred with that where the Prophet had been born. It was also distinguished for its learning, at a time when the Saracens may be said to have enjoyed a monopoly of all the knowledge which then existed. Its schools of philosophy, physic, and astronomy, were famous throughout the Mahommedan kingdoms of Spain and Africa, and were not only resorted to by the youth of these countries, but likewise by Christians. When the Moors were driven out of Spain, Fez became the resort of numerous refugees, who, being superior in knowledge and civilization to their original countrymen, introduced several of the arts, the practice of which for a time retrieved the decaying fortunes of the city. But it gradually sunk with the declension of arts and wealth in Northern Africa; and when the kingdom of which it was the capital became incorporated with the empire of Morocco, it ceased to possess almost any political importance.

Fez is situated upon the slope of several hills, which surround it on every side except the north and north-east. As the town is built on inclined planes, and the ground is unpaved, the streets are very dirty, especially in rainy weather. They are, besides, so narrow, that two horsemen cannot ride together abreast in them; and the gloom thus produced is deepened by the houses (which are very high) having a projection on the first floor. The light is also intercepted by a sort of galleries or passages which connect the upper parts of the houses, and by the high walls which are raised at certain distances from one side of the street to the other, as if to support the buildings. These walls have arched passages, which are shut at night, and all communication between one part of the city and another is by this means cut off. The houses have a mean and ruinous appearance; they are either altogether destitute of windows, or possess but a few which are seldom larger than a common sheet of paper, and being placed very high, are generally covered with blinds. Behind the high walls there are some buildings which in the inside present something like comfort; but it is the general taste of the country to have a mansion composed of a court-yard, surrounded with a colonnade, which forms a kind of gallery both above and below. By these galleries the adjoining rooms are reached, and these commonly receive their light only from the door, which, on this account, is necessarily large. The rooms are long and narrow; the ceiling, composed of planks, is lofty, and sometimes ornamented; and the floors are paved with bricks, Dutch tiles, or marble, according to the wealth of the occupant. The roofs are covered with stamped earth, about one foot thick; and this singular casing, on account of its weight, bulges the walls outwards, and rends them into fissures, whilst it does not protect the houses from rain.

Fez properly consists of two distinct towns, *Fas el Bâlee*, or Old Fez, and *Fas el Jedid*, or New Fez. The latter, which was founded in the thirteenth century, stands on an eminence commanding the old city, and is surrounded with gardens, which abound in all sorts of delicious fruits and odoriferous flowers. This portion of Fez is principally inhabited by Jews. At the bottom of the valley, which is formed by the surrounding hills into a sort of funnel, runs the river *Wed el Juhor*, the river of pearls, so called on account of its value. Besides refreshing vegetation as it passes along, and plentifully supplying the city with water, it is made to turn several water-mills. Fez possesses a vast number of mosques, the finest of which is called *El Caroubin*. It was built during the flourishing period of the city, and is described by Leo Africanus as being a mile and a half in circumference. It is constructed of bricks, stones, and lime, but the architecture is said to be mean. It possesses, however, a great number of gates and arches, and two handsome fountains in the court. There are two other celebrated mosques, one of which (namely, that dedicated to Edris, the founder of the city), is the most frequented in Fez. The palace of the sultan is composed of a great number of court-yards, which serve as entrances to apartments. These consist, besides those for domestic uses, of rooms in which the business of government is transacted. The palace is situated upon an elevation in New Fez. None of the other buildings are in any respect remarkable. There are a great number of shops, to which the inhabitants of the surrounding country daily resort as to a fair, for the purchase of commodities, as they have neither shops nor working-places amongst themselves. Provision-markets are numerous, and the city contains about two hundred caravanserais or inns. The various trades, and the different articles sold, are divided into classes in separate streets, so that a whole street is occupied by those pursuing one species of traffic or art. Fez contains a vast number of public baths, some of which are good, and consist of several rooms heated to different degrees of temperature. There is an hospital richly endowed, but it is occupied solely by lunatics. There are also a great number of schools, the most distinguished of which are established at the mosques of Caroubin and of Muley Edris, in a small house or mosque called *Emdarsa* or academy. In these philosophy is taught, but of course very imperfectly.

The manufactures of Fez consist of woollen hhaïks, sashes, and silk handkerchiefs, slippers of good leather, which they tan remarkably well, red felt caps, some coarse linen cloth, fine carpets, a curious kind of earthenware, weapons of several kinds, saddlers' ware, and copper utensils. There are a few goldsmiths; but the adorning of the person with gold and silver being considered as a sin, this branch of industry is not much patronized. The arts here find little encouragement, and are indeed far inferior to those of Europe, except in the preparation of leather, and in the fabrication of carpets and of hhaiks, which the manufacturers know how to weave as fine and as transparent as gauze. They are also expert in wax-works, weapons, and harness. The heat during the summer is very great; but in other seasons of the year, particularly winter, the climate is agreeable. With regard to the number of inhabitants, much difference of opinion prevails amongst travellers. Mr Jackson estimates the population of the old and new city at 380,000 souls, which is certainly an exaggeration; whilst other authorities reduce the number as low as 60,000 and even 30,000 individuals, which is probably below the mark. The traveller who assumed the fictitious name of Ali Bey was told, whilst he remained there, that Fez contained 100,000 souls, and that before the last plague the inhabitants were double that number. Of this population about 2000 are Jews, who live in the most abject state, on account of the sovereign contempt with which they are treated by the Moors. They are almost all either artisans or merchants, and they have several synagogues, and a market-place, which is well provided. According to Ali Bey, the city is situated in long. 4. 58. 15. W. lat. 34. 6. 3. N. It is 160 miles south of Gibraltar, and 200 north-north-east of Morocco.

FEZZAN, a country of considerable extent in Northern Africa, and situated to the south of Barbary. Its northern boundary is the well of Bonjem, which is situated in lat. 30. 35. 32. N. South of this point it extends, according to Captain Lyon, six degrees and a half of latitude, or about 450 miles, and is bounded in that quarter by what are called the Wells of Meshroo. To the south and south-east is the country of the Tibboos, to the south-west that of the nomadic Tuaricks, and to the north-west the borderers are Arabs. Of this tract of country it is calculated that about 300 miles, stretching from north to south, are cultivated. The greatest breadth is estimated at 200 miles; but the Black Haratch to the east, and other deserts to the south and west, are, according to Horneman, included in its territory. Fezzan may be said to consist of a chain of verdant islands embosomed in an ocean of sand. Fine yellow sand, and a species of gravel, cover the whole surface of the plains, except where the Soudah and Haratch extend. It is only in the immediate neighbourhood of towns that the palm is cultivated, and that corn and esculent plants, of which a little is raised with great difficulty and labour, are produced. The plains of the desert consist of red sand and sand-stone, containing gypsum and rock-salt, associated with beds of dolomite and carbonate of lime. Soda, alum, saltpetre, and sulphur, are also found in this country.

In order to convey as clear and intelligible a view of Fezzan as possible, we shall follow the route generally pursued by travellers in proceeding from Tripoli to Mourzouk, the capital, and thence to the other parts of the country which have been described. About half a mile beyond the walls of Bonjem, which is the northern frontier, stands a Roman castle, situated amongst some high sand hills. It is of an oblong form, having in the centre of each of the walls a large arched gateway, between two strong towers. After leaving this interesting ruin, the traveller proceeds over a barren desert called Klia, the soil of which, where clear of sand, consists of gypsum intermixed with numerous shells. Twenty-two miles from Bonjem the road leads through a defile called Hormut Emhalla, or the Pass of the Army. After crossing a range of table-mountains called Elood, running north-east and south-west, it passes through a stony and very uneven plain, encircled with mountains, to the pass of Hormut Tazzet, which appears to be situated about sixty miles from Bonjem. After clearing this pass, the road opens upon a plain called El Grarat Arab Hoon. The journey now becomes harassing, on account of the scarcity of vegetation and water, and the frequency of sand-winds. The first place of importance that is met with on this route is Sockna, near which are a plantation of palms and two wells of fresh water.

Sockna, which is about half way between Tripoli and Mourzouk, is situated on an immense plain of gravel. It is bounded to the south by the Soudah Mountains, at the distance of about fifteen miles; to the eastward by the mountains of Wadan, at the distance of about thirty miles; to the westward by a distant range of hills; and to the northward by the country above described. The town, which is about a mile in circumference, is walled, and contains, according to Major Denham, considerably more than 3000 persons. The streets are very narrow, and the houses are built of mud mixed with small stones. The water is almost all brackish or bitter. In the immediate neighbourhood there are several hundred thousand date trees, which pay duty to the government. Sockna pays of duty annually about 2000 dollars, exclusively of a tax of one dollar on every 200 date trees. The Tripoli money is the currency of Sockna; and this occasions a considerable loss to the traders, who are obliged to pay their taxes in Spanish dollars, which they purchase at exorbitant prices. The dates grow in a belt of sand, at the distance of two or three miles from the towns; and their quality is far superior to any produced in the north of Africa, in consequence of which they bring a very high price in Tripoli. In the gardens situated about three miles from Sockna, barley, maize, a small quantity of onions, and a few other garden-stuffs, are cultivated. But there is little or no other kind of vegetation, so that all the animals are fed on dates. This place is infested with an immense quantity of flies, attracted probably by the dates, which are preserved in storehouses. The men have in general a clean and neat appearance, whilst the women are pretty and handsome, but remarkable, it seems, for their love of intrigue. The latitude of Sockna is 29. 5. 36. N.

Ten miles east by south from Sockna stands the town of Hoon. It is smaller than the former, but is built and walled in the same manner. Palm groves and gardens approach close to the walls of the town, and completely conceal it. The soil is sand, but it is fertilized and refreshed by little streams from wells of brackish water. Twelve miles east by north of Hoon stands the town of Wadan. Its external aspect is pleasing, being built upon a conical hill, on the top of which are some enclosed houses called the castle; but internally it is inferior to the two other towns in point of neatness, comfort, and convenience. There is here a well of great depth, cut through the solid rock. The bulk of the inhabitants of Wadan are *schereefs*, that is, pretended descendants of the Prophet, and Arabs who act as shepherds. A few miles eastward of the town there is a chain of mountains, which, with the town itself, derives its name from a species of buffalo called *wadan*, which is found here in immense numbers. There is also a great abundance of ostriches amongst these mountains, by hunting which many of the natives obtain a subsistence. At all the three towns, Sockna, Hoon, and Wadan, it is the practice to keep tame ostriches in a stable, and in two years to take three cuttings of the feathers.

The whole way to Mourzouk is now an almost uninterrupted succession of stony plains and gloomy wadys, with no water but that of wells, generally muddy, brackish, or bitter, and placed at widely extended intervals. Sand winds also prevail, and their visitations are at all times harassing, and not unfrequently destructive. Several towns or villages are situated in this long and dreary waste, and they are usually encircled with groves of palm. Sebha, which stands in latitude 27. 3. 8. N., is a mud-walled town, picturesquely situated on a rising ground, and surrounded by a palm grove. Two marches farther on lies Ghroodwa, a small and miserable collection of mud huts. The palms here, which are the property of the sultan, extend from ten to fifteen miles east and west. The leading features of the above remarkable tract of country may be shortly described. The basaltic chain known by the name of the Soudah, or Jebel Assoud, that is, Black Mountains, commences near Sockna, and extends from north to south three days' journey, but in so tortuous a direction as not, according to Major Denham, to exceed thirty-five miles in a straight line. Captain Lyon, however, is of opinion that they stretch nearly a hundred miles from north to south between the parallels of 28. 40. and 27. 30. To the westward they extend as far as the well of Assela, on the road to Shiati, a district to the westward of Sebha, where the red clay hills continue unbroken, and unite with those of Benioleed in Tripoli. To the east they extend three days to a wady called Temelleen, which lies on the way to Zella or Zala near Barca. They form, indeed, a branch or continuation of the mountainous desert called Haratch el Assouat, which was traversed by Horneman in his route from Cairo to Mourzouk. That traveller gives a fearful description of this wild region, so much dreaded by those who have had to traverse it. The mountain presents the appearance of an imperfect cone, and the rock, upon fracture, seemed to Horneman to consist of ferruginous basalt. Range upon range of black and dreary mountains, intersected by narrow and dismal ravines rather than valleys, rose before his view. Here and there, however, the eye was relieved by the sight of patches of vegetation, approaching even to luxuriance, from the rains which fall in this hilly region. Contiguous to the Black lies the White Haratch, a chain of mountains composed of friable limestone, and abounding in petrifactions. To the south of Sockna, the description of the Jebel Assoud, as given by Major Denham, exactly corresponds to that of the Black Haratch. Dr Oudney describes the hills as from 400 to 600 feet in height, the tops being in general tabular, but a few are irregular, and two or three terminate in conical peaks. The sides of all of them are covered with a considerable quantity of debris. Captain Lyon says the chain rises to an elevation of 1500 feet. The lower stratum of these hills is limestone mixed with a reddish clay, superimposed upon which are large masses of tabular basalt and irregular precipices, so common to this formation; whilst the sides occasionally present the usual steplike appearance, and in many instances are overhung by pillars, curved, inclined, and perpendicular. The whole exhibits a scene of barrenness which, according to Major Denham, cannot be perfectly described, either by poet or painter. After these dreary wastes have been passed, the hills of Zeghren commence. They run nearly east and west, are low, long, oval, and truncated at the top, and altogether different from any others which Denham and Oudney had seen. The town of Zeghren, according to the former traveller, is better built than any other in Fezzan.

Mourzouk, the capital of Fezzan, which stands in latitude 25. 54. N. and longitude 15. 52. E., is a walled town, containing about 2500 inhabitants, who are blacks, and who do not, like the Arabs, change their residence. The walls are built of mud, but sufficiently thick and high to guard the place from attack. As a substitute for stones, which are not to be found, the people use baked clay, a substance which is found sufficiently durable, as rain is here unknown. The houses are generally of one story; the doors are low and without hinges, but made to move upon a pivot. The streets are small and narrow, but there are numerous open spaces, destitute of buildings, and covered with sand, on which the camels of the traders remain. Many palms grow in the town, and a few red peppers and onions are cultivated. The street of entrance is a place about a hundred yards broad, leading to the walls which surround the castle, and is extremely elegant. The castle itself is an immense mud edifice, about ninety feet in height, and furnished with small battlements immensely broad at the base, but gradually tapering to about four feet in thickness at the top. Like all the rest of the buildings, the castle has no pretensions to regularity. It is the residence of the sultan, whose apartments are of the best quality, although, on account of the enormous mass of wall, all the rooms are of very small dimensions. The more spacious houses in Mourzouk are constructed in the manner which we shall now endeavour to describe. A large door, sufficiently high to admit a camel, opens into a broad passage, in which there is a stable, and near it a room for slaves. Opposite the stable is a large square apartment, the roof of which is supported by palm trees. In the centre of the roof is an open space, through which the apartment is lighted, for all the houses are destitute of windows. There is generally a divan or seat of mud about eighteen inches high and twelve feet long. From the sides of the large room, doors open into the smaller ones, and a passage leads into a yard which has small houses attached to it, and a well. There are sixteen mosques in Mourzouk, which are covered in, but some of these are very small. The principal one is a low building, destitute of elegance. The burying places are outside the walls, and of considerable extent. Owing to the want of wood, no coffins are used; the bodies are merely wrapped in a mat or linen cloth, and covered with palm branches, over which the earth is thrown. The men of the lower orders of Mourzouk wear a large shirt of white or blue cotton, with long loose sleeves, trousers of the same, and sandals of camel's hide; but the shirt being in general long, many have no other covering. Those of the better sort, however, attire themselves more gaily; and their dress nearly resembles that of the people of Tripoli. The men have little beard, which they likewise keep closely clipped. The dress of the women here differs materially from that generally worn by Moorish females, and their appearance is by no means prepossessing. They plait their hair in thick bobbins, which hang over the forehead, and anoint it so profusely with oil, that this liquid drips down over the face and clothes. From the back hair, however, ornaments of silver or coral are suspended. Other parts of the face and head, such as the ears, are profusely adorned. A woollen handkerchief is fastened to the back of the head, and falling over, is tied by a leather strap under the chin. A blue shirt is generally worn; and a jereed and red slippers complete their equipment. Some of the better class of women wear trousers, and all adorn their persons according to their rank and importance. Both men and women have a singular custom of stuffing their nostrils with a twisted leaf of onions or clover, which has a very disgusting appearance. The natives have a variety of dances, two or three of which are peculiar to the country. In Mourzouk the luxuries of life are very limited, the people subsisting principally on dates. Many of them do not taste corn for months together; but when obtained, it is made into cakes, which are baked in ovens formed of clay in holes in the earth, and heated by burning wood. Tobacco is very generally chewed by the women, as well as by the men; but smoking is the amusement of a great man only.

The revenues of the sultan of Fezzan arise from slaves, merchandise, and dates. For every slave that enters his dominions he receives two Spanish dollars (in some years the number of slaves amounts to 4000); for a camel's load of oil or butter, seven dollars; for a load of beads, copper, or hardware, four dollars; and for one of clothing, three dollars. All Arabs who buy dates pay a dollar of duty on each load before they are allowed to remove it; an impost which, at times, is equal to the market price of the article. Above 3000 loads are sold to them annually. Date trees, excepting those of the kadi and Mamelukes, are taxed at the rate of one dollar for every 200. By this duty, in the neighbourhood of Mourzouk, or, more properly, in the few neighbouring villages, the sultan receives yearly about 10,000 dollars. Of all sheep or goats he is entitled to a fifth. On the sale of every slave he has, in addition to the head money, a dollar and a half, which, at the rate of 4000 slaves annually, gives 6000 dollars. The captured slaves are sold by auction, at which the sultan's brokers attend, bidding high only for the finest. The trees which are his private property produce about 6000 camel-loads of dates, each of 400lbs. weight, which may be estimated at about 18,000 dollars. Every garden pays a tenth part of the corn produced. The gardens are very small, and are watered with great labour from brackish wells, as rain is unknown, and dews never fall. Pomegranate trees and fig trees are sometimes planted in the water channels. Presents of slaves are frequently made, and fines levied. Each town pays a certain sum, which is small; but as the towns are numerous, the average amount may be estimated at 4000 dollars. Add to this the annual excursions for slaves, sometimes bringing 1000 or 1500, of which one fourth are the sultan's property, as well as the same proportion of camels. He alone can sell horses, which he buys for five or six dollars, when half starved, from the Arabs, who come to trade, and cannot maintain them, and makes a great profit by obtaining slaves in exchange for them. All his people are fed by the public, and he has no money to pay, excepting to the pasha, which was formerly 15,000 dollars per annum. There are various other modes by which he extorts money. If a man dies childless, the sultan inherits the greater part of his property; and if he thinks it necessary to kill a man, he becomes his sole heir.

In Mourzouk about a tenth part of the population are in a state of slavery. There are some white families, who are denominated Mamlukes, being descended from renegades, whom the pasha had presented to the former sultan. These families and their descendants are considered as noble, and, however poor and humble their situation may be, they are not a little vain of their title.

The general appearance of the men of Fezzan is plain, and their complexion is black; the women are of the same colour, and ugly in the extreme. Neither sex are remarkable for figure, height, strength, vigour, or activity; and they have a very peculiar cast of countenance, which distinguishes them from other blacks. But they are a cheerful people, fond of dancing and music, and obliging to each other. The men almost all read and write a little; but in every thing else they are very dull and heavy, their affections being cold and selfish, and a kind of general indifference to the common incidents of life marking all their actions. In Mourzouk the men drink a quantity of *lackbi*, as also a liquor called *busa*, which is prepared from dates. The Arabs generally practise hospitality; but amongst the Fezzanese that virtue does not exist. They are, however, very attentive and obsequious to those in whose power they are, or who can repay them tenfold for their pretended disinterestedness. Their religion enjoins that, should a stranger enter whilst they are at their meals, he must be invited to partake; but they generally contrive to evade this injunction by eating with closed doors. The lower classes are, from necessity, very industrious; but amongst people of rank industry is not a characteristic virtue. In regard to morals, they are much upon a level with the people of Tripoli, being both dishonest and insincere. Falsehood is not looked upon as odious unless it be detected.

The lower classes work neatly in leather; they weave a few coarse barracans, and work iron in a solid although clumsy manner. A few likewise work in gold and silver with tolerable skill; and every man is capable of acting as a carpenter or mason. The wood being that of the date tree, and the houses built of mud, very little elegance or skill is required in their construction.

From the constant communication with Bornou and with Soudan, the languages of both these countries are generally spoken, and many of their words are introduced into the Arabic; but the pronunciation is very different from that of the east. Their writing is in the Mogrebyn characters; but they have no idea of arithmetic, and reckon every thing by dots on the sand, ten in a line. Though very fond of poetry, they are incapable of composing it. The Arabs, however, compose a few little songs, which the natives have much pleasure in learning. The women are kept in a state of abject subordination, as is indeed common in all Mahommedan nations. The authority of parents over their children is very great, in fact, unnecessarily despotic. There are no written records of events among the Fezzanese, and their traditions are so disfigured, and so strangely mingled with religious and superstitious falsehoods, that no confidence whatever can be placed in them. Several scriptural passages are selected and believed. The Psalms of David, the Pentateuch, the books of Solomon, and many extracts from the inspired writers, are universally known, and most reverentially considered.

The only towns of any consideration in Fezzan, besides those already described, are Zuela, towards the eastern frontier, on the road to Egypt; Germa, to the west; and Garione, on the road to Bornou. In 1822, Dr Oudney and Captain Clapperton visited Germa, which lies towards the western frontier. It is a walled town, and surrounded by a ditch. At a little distance from it stands the remains of ancient Germa, which appears to have occupied more space than the modern town. It was formerly the capital of Fezzan, and once gave its name to the nation of the Garamantes; at least, unless there are two places of the same name, this must be the ancient Garama, which is described by Pliny as a fine city, the capital of Fazania. The inhabitants of the modern town are very poor, and many of the houses are in ruins. The aspect of the country between this place and Mourzouk is similar to that of the other portions of Fezzan which we have already described. The hills, which stand about a hundred yards apart, are composed of sandstone, finely interstratified with beds of blue and white pipe-clay and alum slate. There is a valley of considerable dimensions, and also several villages. The number of date trees in the eastern and western divisions of this valley is very great. There is here a town called Khraik, situated amidst some fine groves of palm trees, and possessing cultivated patches of ground and wells of good water.

The eastern and southern portions of Fezzan were visited by Captain Lyon. In latitude 25. 55. stands the town of Traghan, which was formerly a place as considerable as Mourzouk. It is situated in a flat desert plain, with its gardens and date groves at a short distance, and contains four mosques; but most of the houses, which are large, are in ruins, and the population is very trifling. Major Denham says that carpets are manufactured here equal to those of Constantinople. The route to Zuela lies entirely through salt plains and stony deserts, with here and there a small village. Zuela, or Zuila, is situated in latitude 26. 11. 48. It was formerly a considerable place, but is now only about a mile in circumference. It contains three mosques and three gates, but there are few good houses in it. The inhabitants are nearly all white; and Captain Lyon observes, that "they are certainly the most respectable, hospitable, and quiet people in Fezzan; and their whole appearance, for they are handsome, and very neatly dressed, bespeaks something superior to the other whites." At a short distance from Zuela are some very interesting ruins, one of them a castle, which must have been a place of great strength, on account of the immense thickness of the walls. These ruined fabrics have been much commented upon, but there is nothing to prove that they were of Roman origin. The next town of any importance is Gatrone, which stands in latitude 24. 47. 57. The country between Zuela and this place is a perfect desert, which in one place consists of a singular mixture of sand and salt. Gatrone is rather pleasantly situated. It is surrounded with sand hills and mounds of earth, covered with a small tree called *athali*. On leaving this place, Captain Lyon proceeded to Tegerhy, the southernmost town in Fezzan, and situated in lat. 24. 4. N. Here the cultivation of the date and palm ceases, and the Arabic gives place to the Bornouese language. The desert comes close to the walls of the town, which is situated to the southward of its palms. The dates are here very fine and plentiful. Tegerhy is commanded by a fort, containing wells of water within the walls. A range of low hills extends to the eastward; and near the town are some salt pools, which are frequented by snipes, wild ducks, and geese. The natives are black, and little superior to savages.

The kingdom of Fezzan is computed to contain about a hundred towns and villages, but the population is thought not to exceed 80,000. It is governed by a sultan, who, although in fact only a viceroy, dependent upon the pasha of Tripoli, possesses absolute sway. In regard to climate, Fezzan cannot be considered as fortunate. In summer the heat is intense, and the south wind, which is very dry, and impregnated with fiery particles, is scarcely supportable even by the natives. The winter, on the other hand, is accompanied with a bleak and penetrating wind blowing from the north, the cold of which is painfully felt even by the natives of a northern climate. Rain falls seldom, and in small quantities; thunder is also rare, but tempests of wind frequently occur. With regard to the soil, we have already spoken at sufficient length. The revenue, as derived from sources already mentioned, is devoted solely to the maintenance of the sultan, his army, and court. The cadi and other officers of justice, the ministers of religion, and even the great officers of state, are maintained from grounds set apart for this purpose, and which are covered usually with gardens, or woods of date trees. The office of cadi or chief judge, to which is also attached that of first minister of religion, is hereditary in a certain family. There is no regular army; but in time of war all who are able to carry arms may be called out.

This country was well known to the ancients under the title of the *Phazania Regio*, and the country of the Garamantes, whose ancient capital has been recognized by Major Rennell in the modern Germa, as already noticed. The name of Fasan or Fezzan seems to have been imposed by the Saracens, when they overran Northern Africa, and established the Mahommedan faith, and ever since it has continued to prevail.

FIAT, in *Law*, a short order or warrant signed by a judge, for making out and allowing certain processes.

FIBRARIÆ, a term anciently applied to minerals of a fibrous structure.

FIBRE, in *Anatomy*, a perfectly simple body, or at least as simple as any thing in the human structure, being fine and slender like a thread, and serving to knit together or connect other parts.

FIBRE is also used to denote one of the slender filaments which compose bodies, whether animal, vegetable, or mineral, but more especially a capillary root of plants.

FIBROSE, or FIBROUS, something consisting of fibres; as, for instance, the roots of plants.

FIBULA, in *Anatomy*, is the outer and smaller of the bones of the leg. See ANATOMY.

FIBULA, in *Antiquity*, a sort of button, buckle, or clasp, made use of by the Greeks and Romans for keeping close or fastening together certain parts of their clothes. The *fibulæ* were of various forms, and often adorned with precious stones. Both men and women wore them in their hair and on their shoes. Players and musicians, by way of preserving the voices of children placed under their care to learn their art, used to compress the prepuce with a *fibula*, lest they should have commerce with women.

Fichte.

FICHTE, JOHN THEOPHILUS, an eminent German metaphysician, was born at Rammenau, a village of Lusatia, on the 19th of May 1762. His father was a ribbon manufacturer, and carried on a small trade in haberdashery. A wealthy person in the neighbourhood having been struck with the extraordinary genius which young Fichte displayed, put him to school, in order to give him an opportunity of cultivating his talents; but the boy becoming impatient of restraint, ran off, and was found sitting on the banks of the Saale, with a map, on which he was endeavouring to trace the way to America. From this period he seems to have prosecuted his studies in an extremely desultory manner; occasionally attending the lectures of the professors of Wittemberg and Leipsic, without devoting his attention exclusively to any particular science. Theology, however, appears to have been his favourite study; and this predilection is conspicuous in many of his subsequent writings, which are distinguished by a singular mixture of philosophical and religious mysticism. When he left the university, his situation was by no means enviable. He possessed no fortune to enable him to indulge in the luxury of philosophical speculation; and, in spite of his decided aversion to every kind of constraint, he was compelled, by the necessity of his circumstances, to accept the situation of tutor in the family of a Prussian gentleman. But his residence in Prussia enabled him to cultivate the acquaintance of the celebrated philosopher of Königsberg, to whose judgment he submitted his first work, the *Critical Review of all Revelations*, which was published anonymously in 1792. In the literary journals, this production, which had attracted considerable attention, was ascribed to the pen of Kant, until the real author made himself known.

Having received fifty ducats from a Polish nobleman, in whose family he had been tutor, Fichte set out on a course of travels through Germany and Switzerland, and afterwards married a niece of Klopstock's at Zurich. In 1793, he published the first part of his *Contributions towards rectifying the Opinions of the Public respecting the French Revolution*. This book, which is written with considerable force and originality, created a great sensation in Germany, and was violently attacked, in consequence of a new and apparently dangerous theory which the author advanced relative to the social contract. The book, however, was perused with great avidity; but the attacks to which we have alluded probably prevented him from publishing the continuation.

The reputation of Fichte was now so well established, that he soon afterwards obtained an appointment to the philosophical chair at Jena, as successor to Reinhold, who had been called to the university of Kiel. Here he commenced his lectures by a programme, in which he endeavoured to give an idea of the *Doctrine of Science* (*Wissenschaftslehre*), the name by which he distinguished the principles of that system of transcendental idealism, which he afterwards more fully developed. In 1794, besides the ordinary duties of his professorship, he every Sunday gave a regular course of lectures, in the form of sermons, *On the Literary Calling*, which was numerously attended. Having established the principles of his doctrine of science, he endeavoured to extend their application to the several departments of philosophy; and with this view he published in 1796 his *Fundamental Principles of the Law of Nature*, and two years afterwards his *System of Morals*. In conjunction with Niethammer, he also published a philosophical journal, in which some articles were inserted, containing certain philosophical views of religion, which were considered by many as tending directly to atheism. Amongst a number of objectionable propositions, it was maintained that God was nothing else than the moral order of the universe; and that, to worship God as a being who could only be represented as existing in time and space, was a species of idolatry. One of Fichte's colleagues called the attention of the Saxon minister Burgsdorf to these heretical propositions; and the consequence was, the rigorous confiscation of the work throughout the whole of Saxony. Fichte and his friend Forberg wrote an *Appeal to the Public*, and several *Apologies*, in order to exculpate themselves from the imputation of atheism. The government of Weimar behaved on this occasion with prudence and moderation; but the celebrated Herder, vice-president of the consistory, took part against Fichte. Eberhard, on the other hand, although hostile to the metaphysical system of Fichte, undertook his defence. The controversy was carried on with great violence, and excited considerable ferment throughout the whole of Germany.

In the mean time Fichte resigned his professorship at Jena, and repaired to Berlin, where he met with a very flattering reception. Here his time was occupied in giving private lectures, and in composing his various writings. In 1800 he published a short treatise, entitled *The Exclusive Commercial State*, containing one of those philosophical systems of political economy from which the praise of ingenuity cannot be withheld; whilst, at the same time, the most cursory view of the general principles on which it is founded must be sufficient to convince us that it could never be advantageously reduced to practice.

About this period Fichte met with a formidable rival in Schelling, who had formerly been a warm partisan of the *Doctrine of Science*, but who now separated from his master, and propounded a new metaphysical theory of his own, which soon acquired a large share of popularity at the German universities, especially at Jena. Fichte indeed endeavoured to modify his theory of the *Doctrine of Science*, and to present it to the world in a new and more attractive form; but he never again recovered the sway which he had formerly exercised over the public mind. Meanwhile, his ardent wish to be again placed in an academical chair was at length gratified by M. de Hardenberg, who in 1805 procured for him the appointment of ordinary professor of philosophy in the university of Erlangen. This appointment was accompanied with the especial favour of being permitted to pass the winter at Berlin, in order to continue his lectures there. But this state of amphibious professorship, as his friends used to call it in jest, did not last long. During the summer of 1805 he delivered at Erlangen his celebrated lectures *On the Essence of the Literary Character* (*über das Wesen des Gelehrten*). The following winter he delivered to a numerous audience the course which he afterwards published under the title of *Guide to a Happy Life*. This was one of those publications in which he attempted to present his metaphysical doctrines to the public in all their sublimity, and, at the same time, with such clearness, as should render them intelligible to common readers.

The disasters which assailed the Prussian monarchy in 1806 were attended with serious consequences to Fichte. Erlangen having ceased to be a Prussian university, he did not await the entry of the French into Berlin, but fled to Königsberg, and thence proceeded to Riga. In the summer of 1807 he delivered a course of philosophical lectures at Konigsberg. The peace which ensued enabled him to return to Berlin, where he pronounced his famous *Orations to the German Nation*, which were enthusiastically read and applauded throughout all Germany. When the university of Berlin was founded, he obtained, through the interest of M. de Humboldt, the situation of rector, which secured to him an honourable revenue, whilst his rank, as first professor of philosophy, gave him great academical influence. His health, however, had suffered considerably from the shocks he had for some time experienced, and he found it necessary to have recourse to the waters of Bohemia, from which he derived great benefit. But his wife was attacked with a nervous fever, in consequence of her attendance on the deserted sick; and although she recovered, Fichte, whose affection would not allow him to leave her for a moment, caught the infection, and died on the 29th of January 1814.

Fichte was small in stature, but stout and well formed; his countenance was expressive of thoughtfulness and determination. In his intellectual character, genius was combined with inflexible firmness; and these qualities enabled him to surmount difficulties which would have overwhelmed a man of less vigorous temperament. In other respects his dispositions were amiable and his morals correct. It was in the academical chair that the genius of Fichte was manifested in its greatest splendour. It was said of him that he was born a professor; and there was indeed a charm in his manner of lecturing which had a powerful influence on the minds of his pupils, several of whom we have heard talk of him with enthusiasm. His fervid and brilliant eloquence, the clearness of his reasoning, and the simplicity and correctness of his language, seemed to diffuse a magic light and colouring over the darkest and most abstruse metaphysical problems. Those who were charmed with his eloquence were easily convinced by his reasoning, and became willing converts to his doctrines. His writings, especially those works in which his peculiar doctrines are propounded in a systematic form, are by no means so attractive as his lectures appear to have been. On the contrary, notwithstanding a constant affectation of strict and simple reasoning, his propositions are enveloped in such a degree of transcendental obscurity, as renders it extremely difficult to comprehend either the basis or the scope of that system of doctrines which he laboured to establish.

Hence it is far from being an easy matter to give an intelligible abstract of the principles of the *Doctrine of Science*, especially as we must necessarily presuppose some acquaintance, on the part of our readers, with the previous metaphysical labours of Kant. Fichte commenced his philosophical career precisely at that period when the writings of Kant had nearly obtained a paramount influence in the German schools, and when men even of superior talents thought it no mean glory to be able to comprehend and illustrate his doctrines. The Kantian theory was confessedly idealistic. Its celebrated author set out with an analysis of the cognitive faculty, and endeavoured to describe its various functions, as well as to ascertain the scope and limits of its legitimate exercise. All our knowledge, according to the critical philosophy, must have a reference to possible experience. Of external objects, or things in themselves (*noumena*), we can have no absolute knowledge; for we can know nothing but what is perceived by the senses, and cognized (if we may be allowed the expression) by our intellectual faculties, according to the laws peculiar to our constitution. These intellectual laws, or subjective forms, tend to combine our knowledge, and to render the field of experience a comprehensible whole. As we can have no knowledge of objects in themselves, but only of their *phænomena*, neither can we have any knowledge of things beyond the sphere of our experience, because these can neither be perceived by our senses nor subjected to the laws of the understanding. All reasoning, therefore, from mere ideas must necessarily be futile, because it has no reference to any corresponding object within the limits of experience. And although we can have no absolute knowledge of objects as they really exist, yet our knowledge of them possesses a subjective reality (that is, a reality with reference to the thinking subject), and may be said to correspond with the objects, because, from the nature of our intellectual constitution, we are incapable of receiving any other impression from them.

Reinhold was one of the earliest partisans of Kant, and one of the most ingenious and most popular commentators on the critical philosophy. But his talents were better adapted for explaining and illustrating the doctrines of others, than for discovering new truths, or inventing any original system of his own; and although an indefatigable student of philosophy, he seems to have never arrived at any settled conviction in metaphysical matters, but to have alternately adopted and abandoned every new theory which was successively presented to his view. After having been for some time enthusiastically devoted to the doctrines promulgated in the *Critical Review of Pure Reason*, which he esteemed the greatest masterpiece of philosophical genius, he at length discovered that Kant had neglected to secure the foundations of the edifice he had raised, and this defect he attempted to supply by his own *Theory of the Faculty of Perception* (*Theorie des Vorstellungsvermögens*). The main proposition laid down and illustrated in this work is nothing more nor less than this: We are compelled by consciousness to admit that every perception presupposes a percipient subject and an object perceived, both of which must be distinguished from the perception to which they relate; thus referring all our knowledge to consciousness as its ultimate principle. In the enunciation of this proposition there is nothing very new or original; but the illustration of this elementary doctrine, which, as a late reviewer of the German metaphysical theories observes, might have formed an excellent subject for a short philosophical dissertation of two or three sheets, is dilated into a work nearly as large as that to which it was intended to serve as a mere introduction; nor is the unnecessary length of the treatise in any measure compensated by the importance of the truths developed, or the ingenuity displayed in the research.

With greater talents and consistency, Fichte, who announced himself as a strict Kantian, attempted to resolve the same problem, and to develope a system which, by deducing all our knowledge from one simple principle, should give unity and stability to the critical theory. In his *Doctrine of Science* (*Wissenschaftslehre*), accordingly, he derives all our knowledge from the original act of the thinking subject in reflecting upon itself. *I am I* (which he expresses by the formula $A = A$), or the absolute position of the I by the I, is in itself the certain principle of all philosophy and of all our knowledge. But the creative energy of the I, in the course of this reflective process, goes still farther. By its own act, also, the I places the *not-I* (objects) as opposed to itself. In reflecting upon itself, as the absolutely active principle, it finds itself either determined by or determining the *not-I*. In the former case, it appears as the *intelligent I*; in the latter, as the *absolutely free, practical I*. Hence the distinction between theoretical and practical philosophy. The idea, then, which pervades the whole theory of Fichte is this: The I, or the thinking subject, is the absolutely active principle, which *constructs* the consciousness, and produces all that exists, by position, contraposition, and juxtaposition. The whole universe, in short, is the product of the I, or thinking subject.

We have thus endeavoured to give a very concise sketch of a theory which we shall not think of pursuing through its various ramifications, as we should despair of making it intelligible to our readers by any length of exposition. Fichte has been praised by his countrymen for his logical and consistent reasoning; but to us it appears that his theory proceeds entirely upon arbitrary assumptions, resting upon no solid foundation. That he displays considerable ingenuity in the development of his ideas we are willing to admit; but we are quite at a loss to perceive the merit of the theory he has advanced, when considered as a system of philosophical truths. The parade of scientific deduction which his reasoning exhibits may impose upon the incautious student; but a careful examination will undoubtedly convince him that the whole is a mere tissue of empty notions, derived from arbitrary and assumed principles.

In attempting to apply the principles of his doctrine of science to the theory of morals and the law of nature, Fichte exhibited many original and paradoxical opinions, along with some very just and ingenious philosophical observations. In his later writings he considerably modified his original theory of the doctrine of science, and produced a system of philosophical and religious mysticism, which appears to have given birth to the transcendental idealism of Schelling, an author who seems to have carried the extravagance of speculative reasoning to its utmost limits.

The following is a list of the works of Fichte.

1. *Versuch einer Kritik aller Offenbarung.* (Critical Review of all Revelation.) Königsberg, 1792, 1793, 8vo.
2. *Ueber den Begriff der Wissenschaftslehre.* (On the notion of a Doctrine of Science.) Jena, 1794, 8vo.
3. *Grundlage der gesammten Wissenschaftslehre.* (Foundation of the whole Doctrine of Science.) Ibid. 1794, 8vo.
4. *Grundriss des eigenthümlichen der Wissenschaftslehre.* (Sketch of the peculiarity of the Doctrine of Science.) Weimar, 1794.
5. *Vorlesungen ueber die Bestimmung des Gelehrten.* (Lectures on the Literary Calling.) Jena, 1794.
6. *System der Sittenlehre.* (System of the Doctrine of Morals.) Jena and Leipsic, 1795.
7. *Beyträge zur Berichtigung der Urtheile des Publicums ueber die Französische Revolution.* (Materials for Rectifying the Opinions of the Public respecting the French Revolution.)
8. *Grundlage des Naturrechts.* (Foundation of the Law of Nature.) Jena, 1796, 1797. 2 vols. 8vo.
9. *Appellation an das Publicum ueber die ihm beygemessenen atheistischen Aeusserungen.* (Appeal to the Public respecting the atheistical expressions imputed to him.) Jena and Leipsic, 1799.
10. *Ueber die Bestimmung des Menschen.* (On the Destiny of Man.)
11. *Der geschlossene Handlesstaat.* (The exclusive Commercial State.)
12. *Sonnenklarer Bericht an das grössere Publicum ueber das eigentliche Wesen der neuesten Philosophie.* (Luminous Report to the greater public on the peculiar Character of the modern Philosophy.) Berlin, 1801.
13. *Wissenschaftslehre.* (Doctrine of Science.) Tübingen, 1802, 8vo.
14. *Vorlesungen ueber das Wesen der Gelehrten.* (Lectures on the Literary Character.) Berlin, 1806.
15. *Die Grundzuge des gegenwärtigen Zeitalters.* (The Characteristics of the present age.) Ibid. 1806.
16. *Anweisung zum seligen Leben.* (Guide to a Happy Life.) Ibid. 1806.
17. *Reden an die Deutsche Nation.* (Discourses to the German nation.) Ibid. 1806.
18. *Die Wissenschaftslehre in ihrem allgemeinsten Umrisse dargestellt.* (The Doctrine of Science exhibited in its most general outline.) Ibid. 1810.
19. *Freidrich Nicolai's Leben und Sonderbare Meinungen, herausgegeben von Schlegel.* (Life and singular opinions of Frederic Nicolai, edited by Schlegel.) Tübingen, 1801.
20. *Antwortschrieben an K. L. Reinhold, auf dessen Beyträge zur leichtern Uebersicht des Zastandes der Philo-*

sophie, &c. (Answer to K. L. Reinhold, on his Materials for acquiring a more easy View of the State of Philosophy, &c.) Tübingen, 1801.

21. *Ueber die einzig mögliche Störung der academischen Freyheit.* (On the only possible disturbance of Academical Freedom.) Berlin, 1812.

22. *Ueber den Begriff des wahrhaften Kriegs, in Bezug auf den Krieg in jahre*, 1813. (On the notion of real war, with reference to the war in 1813.) Tübingen, 1815.

Fichte is also the author of several essays in periodical publications, and particularly in a philosophical journal edited by himself, with the assistance of Niethammer.

Those who are desirous of obtaining more minute information respecting Fichte's philosophical theory, may consult the following works: Tennemann's *Grundriss der Geschichte der Philosophie;* Degerando, *Histoire Comparée*, &c. W. T. Krug, *Briefe ueber die Wissenschaftslehre.* F. W. J. Schelling, *Darlegung des wahren Verhältnisses der Naturphilosophie zu der verbesserten Fichtischen Lehre.* J. Fries, *Reinhold, Fichte und Schelling.* C. F. Bachmann, *Ueber die Philosophie meiner Zeit.* Ancillon, *Essai sur le premier problème de la philosophie;* and *Essai sur l'existence et sur les derniers systèmes de métaphysique qui ont paru en Allemagne.* (K.)

FICINUS, Marsilius, a celebrated Italian, was born at Florence in 1433, and educated at the expense of Lorenzo de' Medicis. He attained a perfect knowledge of the Greek and Latin tongues, and became an eminent philosopher, physician, and divine. He was in the highest favour with Lorenzo and Cosmo de' Medicis, who appointed him a canon of the cathedral church of Florence. He applied himself intensely to the study of philosophy; and whilst others were striving who should be most deeply read in Aristotle, then the only philosopher in fashion, he devoted himself wholly to the study of Plato. He was indeed the first who restored the Platonic philosophy in the west; and for this purpose he translated into Latin the whole works of Plato. He next translated Plotinus; and afterwards the works, or at least part of them, of Proclus, Jamblicus, Porphyrius, and other celebrated Platonists. In his younger days Ficinus lived like a philosopher; too much so indeed, if it be true, as is said, that he did so to the neglect of piety. However, on the arrival of Savonarola at Florence, Ficinus went, with all the world, to hear his sermons; and whilst he attended them for the sake of the preacher's eloquence, he imbibed a strong sense of religion, and henceforward devoted himself more especially to its duties. He died at Correggio in 1499; and, as Baronius assures us, upon the testimony of authors whom he thinks credible, appeared immediately after his death to his friend Michael Mercatus, to whom, it seems, he had promised to manifest himself, in order to confirm what he had taught concerning the immortality of the soul. His writings, sacred and profane, which are very numerous, were collected and printed at Venice in 1516, at Basil in 1561 and 1576, and at Paris in 1641, in two vols. folio. Twelve books of his epistles, amongst which are many treatises, were printed separately in folio at Venice in 1495, and at Nuremberg in 1497, in 4to.

FICUS, the Fig Tree. The *ficus religiosa*, or banian tree, is a native of several parts of the East Indies. It has a woody stem, branching to a great height and vast extent, with heart-shaped entire leaves terminating in acute points. Some of these trees are of amazing size and extent, as they are continually increasing, and, contrary to most other things in animal and vegetable life, seem to be exempted from decay. Every branch from the main body throws out its own roots, at first in small tender fibres, several yards from the ground; but these continually grow thicker until they reach the surface, and then striking in, increase to large trunks, and become parent trees, shooting out new branches from the top, which again in time suspend their roots, and these, swelling into trunks, produce other branches; thus continuing in a state of progression as long as the earth, the parent of them all, contributes her sustenance. The Hindus are particularly fond of the banian tree, which, from its long duration, its outstretching arms, and overshadowing beneficence, they look upon as an emblem of the Deity. Near these trees the most esteemed pagodas are generally erected; under their shade the Brahmins spend their lives in religious solitude; and the natives of all castes and tribes are fond of recreating in the cool recesses, beautiful walks, and lovely vistas of this umbrageous canopy, impervious even to the direct rays of a tropical sun.

FIDD, an iron pin used at sea to splice or fasten ropes together, and made tapering and sharp at one end. There are also fidds of wood, which are much larger than those of iron.

Fidd-*Hammer* is used to signify a hammer, the handle of which is a fidd, or made tapering in that form.

FIDDES, Richard, a laborious English writer, was born at Hunmanby, near Scarborough, in the year 1671. Having received his grammatical education at a private school in the neighbourhood, he was admitted first of Corpus Christi, and then of University College, Oxford; but, after taking the degree of bachelor of arts, in 1693, he returned to his relations, and married the same year a lady of good family and fortune. In 1694 he was ordained priest, and not long afterwards presented to the rectory of Halsham; but this place, situated in a marsh, having proved insalubrious both to himself and his family, his residence on his benefice was dispensed with by his diocesan, upon which he removed to Wickham, where he continued for some time. Being thus unable to display his talents as a preacher, and having a numerous family to support, he resolved to devote himself to literature, and with this view proceeded to London in 1712, where, by the favour of Swift, he was introduced to the Earl of Oxford, who made him one of his chaplains, and procured for him a similar appointment from the queen. But the change of ministry in 1714 overturned all Fiddes' hopes of preferment, and forced him to apply to writing with greater assiduity than ever. Yet he continued to enjoy the esteem of contemporary writers, particularly those of his own party, and was honoured with the friendship of some of the most eminent men of the time. By the interposition of Dr Radcliffe, the degree of bachelor of divinity was conferred upon him by diploma, in the beginning of 1713; and, in 1718, he was honoured with that of doctor by the university of Oxford. In 1725 he died in the house of a friend at Putney, leaving a wife and six children, one of whom, his eldest daughter, married Mr Barcroft, curate of St George's, Hanover Square, who abridged Taylor's *Ductor Dubitantium.* Dr Fiddes was the author of, 1. A Prefatory Epistle concerning some Remarks to be published on Homer's Iliad, occasioned by the proposals of Mr Pope towards a new English version of that poem, 1714, in 12mo; 2. *Theologica Speculativa*, or the first part of a body of Divinity under that title, wherein are explained the principles of Natural and Revealed Religion, 1718, folio; 3. Fifty-two Practical Discourses on several subjects; 4. The Life of Cardinal Wolsey, 1724, folio; 5. Answer to Britannicus, compiler of the London Journal, 1725, being a defence of the Life of Wolsey; 6. A general Treatise of Morality, formed upon the principles of Natural Reason only, 1724, in 8vo; 7. A Preparative to the Lord's Supper; and, 8. A Letter in answer to one from a Freethinker, occasioned by the Duke of Buckingham's Epitaph. Dr Fiddes was an ingenious but not very learned man; he possessed a retentive memory, and was capable of the most intense application ; but his style as a writer is tedious and prolix, and, though commonly judicious, he almost never rises above mediocrity. His misfortunes, towards the close of his life, were chiefly owing to his connection with that party in the state to which, through Swift, he had been led to attach himself upon his arrival in London. (A.)

FIDDLE. See Violin.

FIDE-JUSSOR, in the *Civil Law*, is a surety, or one who obliges himself in the same contract with a principal, for the greater security of the creditor or stipulator.

FIDEI-COMMISSUM, in the *Civil Law*, an estate left in trust with any person, for the use of another.

FIDES, Faith, or Fidelity, one of the virtues deified by the Pagans. She had a temple near the capitol, founded by Numa Pompilius ; but no animals were immolated, nor was any blood spilt, in her sacrifices. During the performance of her rites, her priests appeared in white vestments, with their heads and hands covered with linen, to show that fidelity ought to be sacred.

FIDIUS, in Pagan worship, a god who presided over alliances and promises. This deity, which the Romans borrowed from the Sabines, was also called *Sanctus*, *Semon*, and *Semi-Pater*.

FIELD, in *Heraldry*, is the whole surface of the shield or the continent, so called because it contains those achievements anciently acquired in the field of battle. It is the ground on which the colours, bearing, metals, furs, charges, and the like, are represented.

Field-Book, in *Surveying*, a book in which the angles, stations, distances, &c. are set down.

Field-Colours, or *Camp-Colours*, in war, are small flags of about a foot and a half square, which are carried along with the quartermaster-general, to mark out the ground for the squadrons and battalions.

Field-Pieces, cannons of small calibre, from three to twelve pounders, which are carried along with an army in the field.

Field-Works, in *Fortification*. See Fortification.

FIELDING, Henry, the prince of English novellists, was born at Sharpham-Park, Somersetshire, on the 22d of April 1707. His father, General Edmund Fielding, who had served under John duke of Marlborough, was the third son of Dr John Fielding, canon of Salisbury, who was the fifth son of George earl of Desmond, and brother of William the third earl of Denbigh ; and his mother, the general's first wife, was a daughter of Judge Gould. He was also connected with the noble family of Kingston, which, in the celebrated Lady Mary Wortley Montague, boasted a brighter ornament than rank or title could bestow. Henry Fielding was the only son of the first marriage ; but he had four sisters of the full blood, one of whom, Sarah, was distinguished as an authoress by the history of *David Simple*, and other literary attempts. General Fielding, after the death of his first wife, married a second time, and had a numerous family of sons, one of whom is still remembered as a judge of police by the title of Sir John Fielding. The expense attending so large a family, together with a natural thoughtlessness of disposition on the part of his father, of whose habits economy formed no part, were probably the occasion of Henry being early involved in those embarrassments with which, excepting at brief intervals, he continued to struggle through life.

After acquiring the rudiments of education under the Rev. Mr Oliver, who is supposed to have furnished him with the outline of Parson Trulliber's character, young Fielding was removed to Eton, where he made great progress in the study of the Greek and Roman authors, and imbibed that deep love of classical literature which may be traced throughout all his works. As his father destined him for the bar, he was, at the age of eighteen, sent from Eton to Leyden, where he remained about two years, and is said to have given the most earnest attention to the study of the civil law. Had he been permitted to continue the pursuit in which he had thus engaged, the courts would probably have gained an accomplished lawyer, and the world would have lost a man of genius ; but the circumstances of the father determined the chance in favour of posterity, though against the interests and perhaps the welfare of the son. Remittances, in short, failed, and the young civilian was compelled to return, at the age of twenty, to plunge into the dissipation of London, without a monitor to warn or a friend to support him. His father had indeed promised him an allowance of two hundred pounds a year ; but this, as Fielding himself used to observe, any one might pay who would. Possessed of a strong constitution, a lively imagination, and a keen relish of pleasure, with the capacity of enjoying the present and trusting to chance for the future, Fielding thus found himself his own master in a place where the temptations to every expensive indulgence are numerous, and the means of gratification easily attainable ; and, with reckless improvidence, he squandered in pursuit of pleasure the scanty means which, with strict economy, might have enabled him to begin the world, at the same time entailing upon himself those distresses and misfortunes in which he was ever afterwards involved.

But as disagreeable impressions never remained long upon his mind, and as it was his disposition to look at the brighter side of things, or rather to enliven the gloomiest prospect with the colours which his own fancy cast upon it, he flattered himself that he would find resources in his own wit and genius, and that the difficulties in which he was involved would be overcome by the exertions which he conceived himself capable of making to surmount them. To a man of pleasure, in fact, some resources were indispensably necessary, and Fielding found them in his pen, having no alternative, as he himself used to say, but to become a hackney writer or a hackney coachman. He at first employed himself in writing for the stage, then in high reputation, from having recently engaged the talents of Wycherley, Congreve, Vanburgh, and Farquhar ; his comedies and farces were brought out in hasty succession ; between the years 1727 and 1736, play succeeded play, to the number of eighteen, which were struck off as his necessities impelled, and sank oftener than swam in the theatrical sea upon which he cast them. Of these, the only pieces now known or read are the mock-tragedy of *Tom Thumb*, the translated play of *The Miser*, and the farces of *The Mock-Doctor* and *Intriguing Chambermaid* ; and yet, as Sir Walter Scott justly observes, they are all the production of an author unrivalled for his conception and illustration of character in the kindred department of imaginary narrative. Whilst Fielding was thus living as a man of wit and pleasure about town, seeking and finding amusement in scenes of gaiety and dissipation, and endeavouring to discharge the expense incidental to such a life by the precarious resources afforded by the stage, which, as may easily be supposed, were inadequate for the purpose, he attempted to improve his circumstances by becoming himself the manager of a company ; and having, in 1735, assembled a number of discarded comedians, he proposed that they should perform his own plays, at the little theatre of the Haymarket, under the whimsical title of the Great Mogul's company of comedians. But the project, as might have been expected, did not succeed ; and the company, which seemed to have dropped from the clouds, were under the necessity of disbanding. The whole scheme, in fact, has more the air of a mad frolic than of a serious undertaking. During his theatrical career, which, we have just seen, was by no means brilliant, Fielding, like most authors of the time, found it impossible to interest the public sufficiently in the various attempts which he made to gain their favour, without condescending to flatter their political animosities. In two of his dramatic pieces, *Pasquin* and the *Historical Register*, he displays great acrimony against Sir Robert Walpole, whom, in the year 1730, he had in vain attempted to propitiate by some courtly verses. The keenness of the satire made it felt, and its freedom is supposed to have operated considerably in producing a measure which was then thought necessary to restrain the licentiousness of the stage, and to check that proneness to personal and political satire which had been fostered by the success of the *Beggars' Opera.* But this measure, which consisted in vesting a discretionary power in the Lord Chamberlain to refuse a license to any piece which he should disapprove, was very unpopular at the time, and, like all petty legislation, has done mischief which was not intended by it, and failed to accomplish the object for which it was designed.[1]

About the year 1736, Fielding having, it seems, formed the resolution of settling in life, espoused a young lady of Salisbury, named Craddock, possessed of considerable beauty, and of a fortune of L.1500; and, about the same time, he succeeded, in right of his mother, to a small estate of L.200 per annum, situated at Stower in Derbyshire. With this fortune, which, managed with prudence and economy, might have afforded a decent competence, he retired from London to his seat in the country, resolved to bid adieu to the follies and irregularities of a town life, and to cultivate habits of domestic enjoyment. But having unfortunately carried with him the same improvident disposition to enjoy the present at the expense of the future, which marked his whole life, he soon forgot all his resolutions of amendment; established an equipage with showy liveries; threw open his gates to unbounded hospitality; and suffered his whole substance to be devoured by horses, hounds, retinue, and entertainments. Thus, in less than three years, Fielding found himself landless, homeless, penniless, without any other resource than his abilities, and having brought nothing from the country except that experience of rural life and its pleasures which afterwards enabled him to delineate with such inimitable truth and force the character of Squire Western. Not discouraged, however, he entered himself as a student of law at the Temple, and, after the customary term of manducation, was called to the bar. Fielding had now a profession, and, as he had vigorously applied his powerful mind to the study of the law, it might have been expected that his success would have been in proportion to his assiduity. But various causes conspired to obstruct his rise in the legal profession. In the first place, those persons who have it in their power to advance or retard the practice of a young lawyer, seem to have mistrusted the capacity of a man of wit and pleasure for steady application to business; and Fielding's own conduct was in all probability such as to justify this want of confidence in his regularity. In the next place, disease, the consequence of a free life, came to the aid of dissipation of mind, and interrupted the course of his practice by severe attacks of the gout, which gradually undermined his naturally robust constitution. But amidst all this difficulty and suffering, he pursued his researches with great though irregular vigour; and, as a proof of the eminence to which, in happier circumstances, he might have risen at the bar, he left two manuscript volumes in folio on the Crown Law; a branch to which he had most assiduously applied himself. The exigencies of a family, to which he was tenderly attached, forced him however to have recourse again to the stage, where he attempted to produce a continuation of his own piece, *The Virgin Unmasked;* but as one of the characters was supposed to have been written in ridicule of a man of quality, the Lord Chamberlain refused his license. Political pamphlets, fugitive tracts, newspaper essays, and sometimes farces, were the next means he had recourse to for subsistence; and as his ready pen supplied such productions upon every emergency, he contrived out of the scanty profits to support himself and family. But amidst the anxiety and labour of this precarious mode of life, he had the misfortune to lose his wife; a domestic calamity which so deeply affected him that his reason was for a time endangered by the excess of his grief. All violent emotions, however, are happily transient; Fielding recovered from the blow which had stunned him, though his regret was lasting; and the necessity of procuring subsistence compelled him to resume his literary labours. At length, in the year 1741 or 1742, circumstances led him to engage in a species of composition which he rescued from the degraded state in which he found it, and rendered a classical department in English literature.

The novel of *Pamela*, published in 1740, having raised the fame of Richardson to the highest pitch, Fielding, whether tired of hearing it overpraised,[2] or whether, as a writer for subsistence, disposed to catch at whatever interested the public for the time, or whether, finally, seduced by that malicious spirit of wit which delights to turn into ridicule the idol of the day, resolved to caricature the style, the principles, and the personages of this favourite performance. As Gay's desire to satirize Philips produced *The Shepherd's Week*, so Fielding's purpose to ridicule *Pamela* suggested *The History of Joseph Andrews;* but, in both cases, more especially the latter, a work was executed of infinitely greater merit than could have been expected to arise out of such a design; and the reader received a higher gratification than the author himself appears to have proposed or contemplated. In Fielding's novel there is indeed a fine vein of irony, as will appear from comparing it with the pages of *Pamela;* but the production against which the ridicule was directed is now almost forgotten; whilst *Joseph Andrews* continues to be read for its admirable pictures of manners, and, above all, for the inimitable character of Parson Adams, which alone is sufficient to decide the superiority of Fielding over all novel writers. "His learning, his simplicity, his evangelical purity of mind," says Sir Walter Scott, "are so admirably mingled with pedantry, absence of mind, and the habit of athletic and gymnastic exercises, then acquired at the universities by students of all descriptions, that he may be safely termed one of the richest productions of the muse of fiction. Like Don Quixote, Parson Adams is beaten a little too much and too often; but the cudgel lights upon his shoulders, as on those of the honoured knight of La Mancha, without the slightest stain to his reputation; and he is bastinadoed without being degraded."[1] *Joseph Andrews* was eminently successful; and poor Richardson, whose greediness of praise was only equalled by his extreme sensitiveness to ridicule, felt proportionally offended; whilst his admirers, male and female, took care to echo back his resentment, and to heap Fielding with reproach. The animosity of the idol and his worshippers, in fact, survived the gifted man who had rendered them all ridiculous; and in Richardson's correspondence we find the most ungenerous, not to say malignant, reproaches cast on his memory.[2] But Fielding does not appear to have retorted any of the ill-will in which Richardson and his coterie indulged. If he gave the first offence without provocation, he was also the first to retreat from the contest, and to leave his exasperated antagonists in undisputed possession of the field. Nor was Fielding slow in conceding to Richardson that praise to which his genius entitled him from the liberality of his contemporaries. In the fifth number of the *Jacobite Journal*, he warmly commends *Clarissa Harlowe*, by far the best and most powerful of Richardson's novels, and which, with those scenes in *Sir Charles Grandison* relating to the history of Clementina, contains the passages of deep pathos on which his fame as a writer must finally rest. "Perhaps this is one of the cases," says Sir Walter Scott, "in which one would rather have sympathized with the thoughtless offender, than with the illiberal and ungenerous mind which so long retained its resentment."

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[1] "The regulation," says Sir Walter Scott, "was the cause of much clamour at the time; but licentious satire has since found so many convenient modes of access to the public, that its exclusion from the stage is no longer a matter of interest or regret; nor is it now deemed a violent aggression on liberty that contending political parties cannot be brought into collision within the walls of the theatres, intended, as they are, for places of amusement, not for scenes of party struggle." (*Memoir of Fielding.*) This is no doubt true; but has not the theatre suffered in consequence of the regulation by which all political allusions are excluded from the stage, whilst neither the amount of licentious satire, nor its facilities of gaining access to the public, have been, in the slightest degree, diminished?

[2] This production, many passages of which would now be thought highly indelicate, and condemned as suggestive of licentious ideas, was in those days recommended even from the pulpit. Modern refinement, though it may not have succeeded in banishing immodesty from the heart, has at least had the effect of purifying literary compositions of that grossness which, more or less, deforms almost all those of the last age.

After the publication of *Joseph Andrews*, Fielding had again recourse to the stage, and brought out *The Wedding-Day*, which, though upon the whole unsuccessful, produced him some little profit. This was the last of his theatrical efforts which appeared during his life-time. The comedy of *The Fathers*, in manuscript, was lost by Sir Charles Hanbury Williams, and, when recovered, was performed after the author's death, for the benefit of his family.[3] Besides a variety of fugitive pieces, Fielding published, in 1743, a volume of miscellanies, containing, amongst other things, *The Journey from this World to the next*; a tract of which it is difficult to perceive the scope or aim, although it displays a good deal of Fielding's characteristic humour. His next production was *The History of Jonathan Wild the Great*; a picture of desperate vice, unrelieved by a single indication of human feeling, or even by an accidental deviation into virtue. What object Fielding could have proposed to himself by so revolting a delineation, it is not easy to conjecture. For, besides the disgust produced by the contemplation of wickedness naked and unredeemed, every one must feel, that ascribing a train of fictitious adventures to a real character, has in it something clumsy and inartificial; whilst, on the other hand, it subjects the author to a suspicion of having used as the title of his book the name of an infamous depredator, in the hope of connecting the one with the popular renown of the other. At the same time, there are not many passages in Fielding's works more strongly marked with his peculiar genius, than the scene between Jonathan Wild and the Ordinary, in Newgate. Besides these more permanent proofs of his application to literature, Fielding employed his ready pen in most of the political and literary controversies of the times. He conducted one paper, called *The Jacobite Journal*, the object of which was to eradicate those feelings and sentiments which had already been so effectually crushed on the field of Culloden; and he either entirely composed or had a principal share in *The True Patriot* and *The Champion*, periodicals of the same class. Being attached to the principles of the Revolution, and to the settlement of the succession in the family of Brunswick, he steadily advocated what was then called the Whig cause; but whilst far inferior writers were enriched out of the secret-service money with unexampled prodigality, his zeal and ability remained long unnoticed, and never met with any suitable recompense.

As it was impossible, however, that such a man could be altogether overlooked, Fielding, in 1749, received a small pension, together with an appointment as a justice of peace for Westminster; an office then considered as disreputable, and of which he was at liberty to make the most he could by the worst means he chose. At this period the magistrates of Westminster, being paid by fees for their services to the public, were thence termed trading justices; and in general they appear to have deserved this opprobrious appellation; for the mean and wretched system on which they were remunerated making it their interest to inflame petty disputes, to wring out of thieves and pickpockets a portion of their unhallowed gains, and thus to traffic, as it were, in guilt and misery, seemed equally well calculated to encourage crime, and to degrade those whose ostensible duty it was to repress it. The habits of Fielding, who was never very select in his society, cannot be supposed to have been improved by the position into which he was now thrown; and from a humiliating anecdote told by Horace Walpole,[1] in his usual lively but unfeeling manner, it would appear, even after allowance is made for the aristocratical exaggeration of the narrator, that his mind had sunk to the level of his situation. Yet, though the circumstances attending his official situation tended to foster the careless and disreputable habits which he was unfortunately but too prone to indulge, it is consoling to observe that Fielding's principles remained unshaken, and that there is no foundation whatever for the imputation of venality which, from the popular discredit attaching to his office, and his own thoughtless extravagance, the ill-natured world were at one time but too ready to cast upon him. His own account of his conduct respecting the dues of the office on which he depended for subsistence has been confirmed by Mr Murphy, and never doubted or denied. "I will confess," says he, "that my private affairs at the beginning of winter had but a gloomy aspect; for I had not plundered the public, or the poor, of those sums which men, who are always ready to plunder both as much as they can, have been pleased to suspect me of taking; on the contrary, by composing instead of inflaming the quarrels of porters and beggars (which, I blush when I say, hath not been universally practised), and by refusing to take a shilling from a man who most undoubtedly would not have had another left, I had reduced an income of L.500 a year, of the dirtiest money upon earth, to little more than L.300, a considerable portion of which remained with my clerk." Nor was this all. Whilst Fielding thus evinced his disinterestedness as a magistrate, he endeavoured, by various suggestions, to check the growth of crime and depravity. His *Inquiry into the Increase of Thieves and Robbers* contains several valuable hints which succeeding statesmen have adopted, and some which have not yet received the attention they deserve. He was the first to expose the injurious effects of the frequency of pardons, rendered necessary by the reckless multiplication of capital punishments; and he had the merit of directing public attention to that swelling imposthume of the state, pauperism, with the consequences to be apprehended from the state of the poor laws and the mode in which they were administered. He afterwards published a scheme for the provision of the poor, which showed that he was fully sensible of the evil, without being able to suggest an effectual or practical remedy; but although his project for restricting them to their parishes, and providing for them in workhouses, was not approved of, it has never been disputed that his treatise exhibits both the knowledge of the magistrate and the picturesque expression of the novel writer. He also published a *Charge to the Grand Jury of Middlesex*, and some *Tracts concerning Law Trials*, which are considered as valuable.

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[1] The style of this piece is said in the preface to be an imitation of Cervantes; but it bears more resemblance to that of the *Roman Comique* of Scarron, from whom Fielding appears to have copied the mock-heroic style, which narrates ludicrous events in the language of the classical epic; a vein of pleasantry, however, which is soon wrought out, and which, if frequently employed, is apt to degenerate into pedantry.

[2] Richardson, being well acquainted with Fielding's sisters, took occasion to complain to them, not of their brother's usage of himself (this would have been natural and honest), but of his unfortunate predilection for what was mean and low in character and description. The following passage is remarkable, first for the unexampled presumption of the writer, who thus constitutes himself the judge paramount of Fielding's qualities; and, secondly, for the malignant indelicacy which could obtrude such observations on the sister of a rival: "Poor Fielding! I could not help telling his sister that I was equally surprised at and concerned for his continued lowness. Had your brother, said I, been born in a stable, or been a runner at a spunging-house, one should have thought him a genius, and wished he had had the advantage of a liberal education, and of being admitted into good company!" The man who could be guilty of such deliberate brutality as is here complacently chronicled, would not have scrupled to employ more criminal means to gratify his animosity, if he had not been restrained either by innate cowardice or a salutary fear of the laws. After this, however, we cannot be surprised to find Richardson alleging that Fielding was destitute of invention and talents; that the run of his best works was nearly over; and that, as an author, he would soon be forgotten!

[3] The following anecdote, which is given by former biographers, shows the carelessness of Fielding respecting his reputation as a dramatist: "On one of the days of its rehearsal (that is, the rehearsal of *The Wedding-Day*), Garrick, who performed a principal part, and who was then a favourite with the public, told Fielding he was apprehensive that the audience would make free with him in a particular passage, and remarked that, as a repulse might disconcert him during the remainder of the night, the passage should be omitted; "No, d—n 'em," replied he; "if the scene is not a good one, let them find *that* out." Accordingly the play was brought out without alteration, and, as had been foreseen, marks of disapprobation appeared. Garrick, alarmed at the hisses he met with, retired into the green-room, where the author was solacing himself with a bottle of champagne. He had by this time drank pretty freely; and, glancing his eye at the actor, while clouds of tobacco issued from his mouth, cried out, "What's the matter, Garrick? what are they hissing now?" "Why, the scene that I begged you to retrench," replied the actor; "I knew it would not do; and they have so frightened me that I shall not be able to collect myself again the whole night." "Oh, d—n 'em," rejoined he, with great coolness, "they *have* found it out, have they?"

Before publishing his scheme for the provision of the poor, however, Fielding made himself immortal by the production of *Tom Jones, or the History of a Foundling;* a work composed under all the disadvantages incident to an author alternately harassed by his disagreeable magisterial duties, and pressed by the necessity of hurrying out some ephemeral essay or pamphlet to meet the demands of the passing day.[2] In these painful and precarious circumstances was the first of English novels given to the public, who had not hitherto seen any works founded upon the plan of painting from nature, and who, consequently, were quite unprepared for a work constructed on such a principle. Even Richardson's novels are but a step removed from the domain of the old romance; and, though approaching more nearly to the ordinary course of events, still resemble it by dealing in improbable incidents, exaggerated delineations, and characters swelled out beyond the ordinary proportions of humanity. *Tom Jones*, on the other hand, is truth and human nature itself, and therein consists the incalculable advantage which it possesses over all previous fictions of this particular kind. Fielding is the Hogarth of novelists; and he painted manners with the hand of a master. *The History of a Foundling* was received with unanimous acclamation by the public, and proved so productive to Millar, the publisher, that he handsomely added L.100 to the L.600 for which he had purchased the work from the author.

"The general merits of this popular and delightful work," says Sir Walter Scott, "have been so often dwelt upon, and its imperfections so frequently censured, that we can do little more than hastily run over ground which has been so repeatedly occupied. The felicitous contrivance and happy extrication of the story, where every incident tells upon and advances the catastrophe, while at the same time it illustrates the characters of those interested in its approach, cannot too often be mentioned with the highest approbation. The attention of the reader is never diverted or puzzled by unnecessary digressions, or recalled to the main story by abrupt and startling recurrences; he glides down the narrative like a boat on the surface of some broad navigable stream, which only winds enough to gratify the voyager with the varied beauty of its banks. One exception to this praise, otherwise so well merited, occurs in the story of the Old Man of the Hill; an episode which, in compliance with a custom introduced by Cervantes, and followed by Le Sage, Fielding has thrust into the midst of his narrative, as he had formerly introduced the History of Leonora, equally unnecessarily and inartificially, into that of *Joseph Andrews*. It has also been wondered why Fielding should have chosen to leave the stain of illegitimacy on the birth of his hero; and it has been surmised that he did so in allusion to his own first wife, who was also a natural child. A better reason may be discovered in the story itself; for had Miss Bridget been privately married to the father of Tom Jones, there could have been no adequate motive assigned for keeping his birth secret from a man so reasonable and compassionate as Allworthy.

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[1] "Rigby gave me a strong picture of nature. He and Peter Bathurst, t'other night, carried a servant of the latter's, who had attempted to shoot him, before Fielding, who, to all his other vocations, has, by the grace of Mr Lyttleton, added that of Middlesex justice. He sent them word he was at supper; they must come next morning. They did not understand that freedom, and ran up, where they found him banquetting with a blind man, a wh—, and three Irishmen, on some cold mutton, and a bone of ham, both in one dish, and the dirtiest cloth. He never stirred or asked them to sit. Rigby, who had seen him come so often to beg a guinea of Sir C. Williams, and Bathurst, at whose father's he had lived for victuals, understood that dignity as little, and pulled themselves chairs, on which he civilized." (*Letters from the Hon. Horace Walpole to George Montague, Esq.* p. 58, London, 1818.) It ought to be added, however, that Walpole, though he has here stigmatized the lowness of Fielding's society and habits, has elsewhere done justice to his talents. In *The Parish Register of Twickenham*, or poetical account of that place, Fielding's residence in the neighbourhood is not forgotten; that residence,

Where Fielding met his bunter muse,
And as they quaff'd the fiery juice,
Droll nature stamp'd each lucky hit
With unimaginable wit.

[2] *Tom Jones* is inscribed to the Hon. Mr, afterwards Lord Lyttleton, in a dedication where he intimates that, without his assistance, and that of the Duke of Bedford, the work would never have been composed, inasmuch as the author had been indebted to them for the means of subsistence whilst engaged in composing it. Ralph Allen, the friend of Pope, is also alluded to as one of his benefactors, but, by his own desire, not named. This modest and munificent patron of merit is said to have made Fielding a present of L.200 at one time, and that before he was personally acquainted with the object of his bounty; an act of rare generosity, and, from the manner in which it was performed, fully confirming the truth of Pope's beautiful couplet:—

Let modest Allen, with ingenuous shame,
Do good by stealth, and blush to find it fame.

"But even the high praise due to the construction and arrangement of the story is inferior to that claimed by the truth, force, and spirit of the characters, from Tom Jones himself down to Black George the game-keeper and his family. Amongst these, Squire Western stands alone; imitated from no prototype, and in himself an inimitable picture of ignorance, prejudice, irascibility, and rusticity, united with natural shrewdness, constitutional good humour, and an instinctive affection for his daughter,—all which qualities, good and bad, are grounded upon that basis of thorough selfishness, natural to one bred up from infancy where no one dared to contradict his arguments or to control his conduct. In one incident alone we think Fielding has departed from this admirable sketch. As an English squire, Western ought not to have taken a beating so unresistingly from the friend of Lord Fellamar. We half suspect that the passage is an interpolation. It is inconsistent with the squire's readiness to engage in rustic affrays. We grant a pistol or sword might have appalled him; but Squire Western should have yielded to no one in the use of the English horsewhip; and as, with all his brutalities, we have a sneaking interest in the honest jolly country gentleman, we would willingly hope there is some mistake in this matter.

"The character of Jones, otherwise a model of generosity, openness, manly spirit, mingled with thoughtless dissipation, is, in like manner, unnecessarily degraded by the nature of his intercourse with Lady Bellaston; and this is one of the circumstances which incline us to believe that Fielding's ideas of what was gentleman-like and honourable had sustained some depreciation, in consequence of the unhappy circumstances of his life, and of the society to which they condemned him.

"A more sweeping and general objection was made against the *History of a Foundling* by the admirers of Richardson, and has been often repeated since. It is alleged, that the ultimate moral of *Tom Jones*, which conducts to happiness, and holds up to our sympathy and esteem a youth who gives way to licentious habits, is detrimental to society, and tends to encourage the youthful reader in the practice of those follies to which his natural passions and the usual course of the world but too much direct him. French delicacy, which on so many occasions has strained at a gnat and swallowed a camel, saw this fatal tendency in the work, and by an *arrêt* discharged the circulation of a bungled abridgment by De la Place, entitled a translation. To this charge Fielding himself might probably have replied, that the vices into which Jones suffers himself to fall are made the direct cause of placing him in the distressful situation which he occupies during the greater part of the narrative; whilst his generosity, his charity, and his amiable qualities, become the means of saving him from the consequences of his folly. But we suspect with Dr Johnson, that there is something of cant both in the objection and in the answer to it. 'Men,' says that moralist, 'will not become highwaymen because Macheath is acquitted on the stage;' and we add, they will not become swindlers and thieves because they sympathize with the fortunes of the witty picaroon Gil Blas, or licentious debauchees because they read *Tom Jones*. The professed moral of a piece is usually what the reader is least interested in; it is like the mendicant, who cripples after some splendid and gay procession, and in vain solicits the attention of those who have been gazing upon it. Excluding from consideration those infamous works, which address themselves directly to awakening the grosser passions of our nature, we are inclined to think, the worst evil to be apprehended from the perusal of novels is, that the habit is apt to generate an indisposition to real history and useful literature; and that the best which can be hoped is, that they may sometimes instruct the youthful mind by real pictures of life, and sometimes awaken their better feelings and sympathies by strains of generous sentiment and tales of fictitious wo. Beyond this point they are a mere elegance, a luxury contrived for the amusement of polished life, and the gratification of that half love of literature, which pervades all ranks in an advanced stage of society, and are read much more for amusement than with the least hope of deriving instruction from them. The vices and follies of Tom Jones are those which the world soon teaches to all who enter on the career of life, and to which society is unhappily but too indulgent; nor do we believe, that in any one instance the perusal of Fielding's novel has added one libertine to the large list, who would not have been such had it never crossed the press. And it is with concern we add our sincere belief, that the fine picture of frankness and generosity exhibited in that fictitious character has had as few imitators as the career of his follies. Let it not be supposed that we are indifferent to morality, because we treat with scorn that affectation which, while in common life it connives at the open practice of libertinism, pretends to detest the memory of an author who painted life as it was, with all its shades, and more than all the lights which it occasionally exhibits, to relieve them. For particular passages of the work, the author can only be defended under the custom of his age, which permitted, in certain cases, much stronger language than ours. He has himself said, that there is nothing which can offend the chastest eye in the perusal; and he spoke probably according to the ideas of his time. But in modern estimation, there are several passages at which delicacy may justly take offence; and we can only say, that they may be termed rather jocularly coarse than seductive; and that they are atoned for by the admirable mixture of wit and argument by which, in others, the cause of true religion and virtue is supported and advanced.

"Fielding considered his works as an experiment in British literature; and therefore he chose to prefix a preliminary chapter to each book, explanatory of his own views, and of the rules attached to this mode of composition. Those critical introductions, which rather interrupt the course of the story, and the flow of the interest at the first perusal, are found, on a second or third, the most entertaining chapters of the whole work."

The publication of *Tom Jones* placed Fielding at the head of English novellists, but it seems to have been attended with little or no advantage to his fortune beyond the temporary relief afforded by the copy-money. His last work of importance was *Amelia*, which may be considered as a continuation of *Tom Jones;* but we have not the same sympathy for the ungrateful and dissolute conduct of Booth, as for the youthful, and on that account somewhat excusable, follies of Jones. The character of Amelia is said to have been drawn for Fielding's second wife; and if, as has been alleged, he put her forbearance to tests of the same kind, it must also be confessed that he has in some degree repaid her by the picture which he has drawn

Fielding.

of her purity, delicacy, and tenderness. *Amelia* was published in 1751 by Millar, who paid a thousand pounds for the copyright, and contrived to reimburse himself by an ingenious stratagem which he practised on the trade. In 1752, Fielding, unmoved by former failures, commenced a literary newspaper and review, to be published twice a week, which he entitled the *Covent-Garden Journal;* but although his ready pen, sharp wit, and classical attainments, highly fitted him for conducting a work of this kind, it was his failing to embroil himself in the party squabbles or literary feuds of the day; and on this occasion it was not long ere he involved himself in a quarrel with Dr Hill and other periodical writers, amongst whom we regret to mention Smollett, a man possessed of kindred genius, and second only to Fielding in that department of literature where both so eminently excelled. The warfare was of short duration, and neither party would derive honour from an inquiry into the cause or the conduct of hostilities.

Meanwhile Fielding's strength was fast decaying; a complication of disorders having terminated in a dropsical habit, which totally undermined his naturally robust constitution. But as the Duke of Newcastle, then prime minister, was desirous of receiving assistance from him in the formation of a plan for the prevention of secret robberies, and for improving the police of the metropolis, Fielding undertook, for the small consideration of L.600, to be paid by government, to extirpate several gangs of daring ruffians, who then infested London and its vicinity; and, though his health was thus impaired, he continued to superintend the conduct of his agents, to take evidence, and to make out commitments, until this great object was accomplished. The exertions which were thus rendered necessary, however, proved fatal to his exhausted frame, which was now suffering under dropsy, jaundice, and asthma. The Bath waters were tried, but in vain; and various modes of cure or alleviation were resorted to, though with little effect. As a last resource, therefore, his medical advisers recommended him to try the effect of a milder climate; and with this view he undertook a voyage to Lisbon, of which he has left a record, written with a hand trembling almost in its latest hour.[1] Fielding, however, reached that city alive, and remained there two months; but he was unable to continue his proposed literary labours. The hand of death was upon him; and in the beginning of October 1754 he terminated his earthly career, in the forty-eighth year of his age, leaving behind him a widow and four children. "Thus lived, and thus died," says Sir Walter Scott, "at a period of life when the world might have expected continued delight from his matured powers, the celebrated Henry Fielding, father of the English novel, and in his powers of strong and national humour, and forcible yet national expression of character, unapproached as yet even by his successful followers." (See Murphy's *Life and Genius of Fielding;* Chalmers' *Biog. Dict.* art. *Fielding;* and, above all, Sir Walter Scott's *Prefatory Memoir,* in Ballantyne's *Novelist's Library.*) (A.)

FIERI FACIAS, in *Law*, a writ that lies where a person has recovered judgment for debt or damages in the king's court, by which the sheriff is commanded to levy the debt and damages on the defendant's goods and chattels.

FIESOLE, a city of the grand duchy of Tuscany, in Italy, in the province of Florence. It occupies an elevated situation, is the see of a bishop, and has a cathedral, several churches, and but few inhabitants. It is a place of great antiquity, having been in remote ages one of the twelve eminent cities of Etruria. It has now several country-seats of the Florentine nobles.

FIFESHIRE is situated between 56° 3′ and 56° 25′ north latitude, and bounded by the River and Frith of Tay on the north, by the German Ocean on the east, by the Frith of Forth on the south, and by parts of Kinross, Perth, and Clackmannan on the west. Its greatest length is about fifty miles, and its greatest breadth about twenty miles; but its medium length from east to west is only about thirty-six miles, and its breadth from north to south about fourteen miles. Its area, therefore, contains about 504 square miles, or 322,560 English acres.

The most prominent features in Fifeshire, when viewed at a distance from the south, are the two Lomond Hills, in the middle of the county, the westmost of which rises 1721 feet above the level of the sea; Largo Law, farther east, 952 feet; and Kelly Law, 810 feet. Besides these, there are numerous other elevations scattered throughout the county; and indeed it is everywhere found to present a pleasant variety of hill and valley, stretching in general from west to east, parallel to the Tay and the Forth. The principal valley is that through which the river Eden flows, and is called the Howe of Fife. It lies to the north of the Lomond range of hills, and divides the county into the northern and southern portions. The valleys of the Leven and the Ore, and the valleys connected with, or as it were opening into, the Howe of Fife, are of much smaller extent and appearance. The hills and country on the north of the Howe of Fife seem to be a continuation of the Ochil Hills, and have been considered by geologists as belonging to the old red sandstone formation. The prevailing rocks found there are red and white sandstone, amygdaloid, compact felspar, claystone, clinkstone, greenstone, basalt, traptuff, and wacké. Limestone is also found near Newburgh, and shell marl in abundance at Rossie and Lords Carnie.

The mineral structure of the Howe of Fife, and of some of the other valleys, has never yet been minutely explored. Sandstone quarries, however, have been opened at different places, and here and there are to be seen eminences of gravel regularly stratified. The rocks of the southern division of Fifeshire chiefly belong to the coal formation of geologists, and form a portion of the great coal field of the Forth. Here glance coal, or blind coal as it is sometimes called, is met with occasionally; and slate coal, pitch coal, and cannel coal, are occasionally found together in the same bed, and sometimes in separate strata in the same pit.

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[1] Of his departure for Lisbon he has himself left the following melancholy record, in which his situation is painted a thousand times better than could have been done by any pen but his own: "On this day, Wednesday, June 26, 1754, the most melancholy sun I had ever beheld arose, and found me awake at my house at Fordhook. By the light of this sun, I was, in my own opinion, last to behold and take leave of some creatures on whom I doated with a mother-like fondness, guided by nature and passion, and uncured and unhardened by all the doctrine of that philosophical school, where I had learned to bear pains, and to despise death. In this situation, as I could not conquer nature, I submitted entirely to her, and she made as great a fool of me as she had ever done of any woman whatsoever; under pretence of giving me leave to enjoy, she drew me in to suffer, the company of my little ones during eight hours; and I doubt not whether, in that time, I did not undergo more than in all my distemper. At twelve precisely my coach was at the door, which was no sooner told me, than I kissed my children, and went into it with some little resolution. My wife, who behaved more like a heroine and philosopher, though at the same time the tenderest mother in the world, and my eldest daughter, followed me. Some friends went with us, others here took their leave; and I heard my behaviour applauded, with many murmurs and praises to which I well knew I had no title." (*Voyage to Lisbon*, p. 1.) This affecting passage remains a singular example of Fielding's natural strength of mind; and, indeed, the whole of the *Journey to Lisbon* shows that, whilst struggling at once with the depression and the irritability of disease, he could still exhibit a few flashes of that bright wit which used to set the world in a roar. "His perception of character, and power of describing it," says Sir Walter Scott, "had not forsaken him in those sad moments; for the master of the ship in which he sailed, the scolding landlady of the Isle of Wight, the military coxcomb who visits their vessel, are all portraits marked with the master-hand which traced Parson Adams and Squire Western."

From a charter dated in March 1291, it would appear that coal has been worked in this county for more than five centuries. William de Oberville there grants liberty to the convent of Dunfermline to open a coal-pit in his lands of Pityncreiff. But it has been alleged that this is not the first instance of a Scottish charter containing a right to work coal; for one dated 1284–85 is said to exist, from which it may be inferred that coal was worked in the lands of Tranent before that period. The principal coal works in the county at present are those in the parishes of Dunfermline, Dysart, Wemyss, and Markinch; but coal is also worked at present, or has been so formerly, in the parishes of Torryburn, Inverkeithing, Dalgety, Burntisland, Abbotshall, Auchterderran, Scoonie, Largo, and Pittenweem.

In the southern division of Fifeshire limestone is also abundant. The lime works at Charleston, belonging to the Earl of Elgin, are perhaps the greatest in Scotland. Upwards of 100,000 tons are said to be raised annually in his lordship's quarries; which quantity is either shipped or sold in its native state, or after being calcined. The Carron Company also work out extensively the lime on their estate of Newbigging, in the parish of Burntisland, and ship it at the harbour of Starleyburn, on the Forth, for their works at Carron, where it is used for smelting iron. The great iron work on the Devon is also supplied for a similar purpose with limestone from Whinnyhall, in the parish of Burntisland. The limestone in the interior of the county is likewise transported across the Howe of Fife, and by the way of Newburgh, to the Carse of Gowrie, and Forfarshire and Perthshire.

Sandstone abounds in the southern division of the county; and, in many places, it is of a fine grain and durable nature. The principal quarry in the county is at Cullello, in the parish of Aberdour. The stone obtained from it, in consequence of its superior quality, has been used for some of the finest buildings in Edinburgh, as well as carried over land to great distances. Ironstone also abounds in the coal field, and was once worked extensively at Balgonie, where it was smelted. But it is now chiefly worked at Dysart, and sold to the Carron Company. The other rocks found in this coal field are bituminous shale, slate clay, flinty slate, wacké, traptuff, amygdaloid, greenstone, and basalt. Stones somewhat resembling the precious garnet are sometimes found imbedded in the traptuff at Ely, and are known by the name of the Ely rubies. Copper and zinc are also said to have been met with in different places, and lead has been worked in the Lomond Hills. Marl is also often found in the marshes and in the lakes, and sometimes in dry seasons it is carried away for agricultural purposes.

There are none of the mineral springs in the county so remarkable as to be at present frequented as watering places. Those which arise in the coal fields are frequently chalybeate. One of the two mineral springs at Dysart yields a chalybeate water of considerable strength. In the Howe of Fife springs issuing from the sandstone or gravel are said to be frequently saline. But in the portions of the county where the trap-rocks abound, the springs, whatever virtues they are supposed to possess, seldom yield any thing but pure water. From the Inkcraig of Carnock, adjoining to a dam dike, there is said to issue a spring of petroleum, from which there constantly drops a liquid resembling ink.

The only streams of any note in the county are the Leven and the Eden. The former, which issues from Loch Leven, in Kinross-shire, flows eastward, through a beautiful strath, by Leslie, Balgonie, and Balfour, and, after a course of about twelve miles, during which it receives the Lothrie and the Orr, falls into the Frith of Forth at the town of Leven. From the declivity of its channel, it is well fitted for impelling machinery; and accordingly a great many mills and other works have been erected on its banks. An act of parliament was lately obtained, the chief object of which was the erection of works and the construction of mechanism, to regulate the rise or fall of the water in the lake, and to restrain or increase the flow of the river for the benefit of the bleachfields and other manufactories erected upon its banks; and these objects have been accomplished at a sum considerably exceeding L.30,000. The Leven abounds in salmon and sea trout, and where it falls into the sea there is a salmon fishery. The Eden is formed by the confluence of several small streams in the parish of Strathmiglo on the west, near the boundary of Fife with Kinross-shire, and winding slowly through the level valley, and sometimes overflowing its banks, passes the town of Cupar, and loses itself in the German Ocean about eighteen miles from its source. It contains trout, pike, and eels, and has also a salmon fishery where it discharges itself into the sea. The Guard Bridge over this river, consisting of six arches, was built in the beginning of the fifteenth century.

There are a number of lakes in the county, none of them very large, but some of them very beautiful, such as those at Lindores, Kilconquhar, Kinghorn, Lochgellie, Camilla, Lochfittie, and Otterston. Most of these lakes abound in pike, perch, and eels, and are frequented by ducks, coots, and other water fowl. The county once contained many more lakes, which have been drained at great expense. Amongst these, the most considerable are the lakes of Rossie and Lochore. Their beds are now used in raising valuable crops.

From the extensive drainage of the lakes, and the general improvement of the county, its climate within the last forty years has been considerably ameliorated, and is more free than formerly from the injurious fogs which used to arise from the lochs and damp lands. At present the climate may be described as mild. The harvests are early, and snow seldom lies long. As the direction of the hills in the county is from east to west, it is much exposed to the easterly winds, which often check vegetation in the spring months; and hoar frosts are not unfrequent so late as the middle of June. The heaviest rains are from the south-west, the south-east, and the north-east, and the winds from the two last points bring the heaviest falls of snow. The driest and most steady weather comes from the north-west and east.

Four fifths of the county at least are considered at present as arable, and the remainder consists of hills, marshes, moors, lands covered with drifted sand and chiefly bearing bent, extensive plantations, and high roads. Along the banks of the Forth, above the trap-rocks, and the tract of country on the north of the Howe of Fife, the soil is for the most part of excellent quality, being rich loam, good clay, and gravel mixed with loamy earth. The soil from St Andrews to the western parts of the county, where the strata underneath consist of freestone, coal, or slate, is in general greatly inferior. The Howe of Fife contains a considerable proportion of moor and moss, besides a tract of loam partly deep and moist, and partly light and dry.

Within the last forty years extensive woods have been planted in the county. For instance, there is a forest of Scotch firs in the Howe of Fife, stretching for many miles in length, on the Leven, Crawfurd, and other estates. Forests of all kinds of trees have also been planted on the Raith estate, by Mr Ferguson, the proprietor; and a princely ride along the Cullello Hills, of considerable length, was formed and adorned with plantation several years ago by Mr Stuart of Dunearn. Indeed there is hardly a proprietor in Fifeshire of the least consequence who has not contributed extensively to the creation of forests and pleasure grounds on his estate. The oldest woods in Fife are round Leslie House, the seat of the Earl of Rothes.

There are a great number of splendid mansions in the county belonging to the nobility and gentry, and situated upon their estates. There are some of these estates pretty large, and a greater number above L.500 Scotch of valuation than in any other county in Scotland. But of the 638 estates which it contained in 1811, 491 were below that amount. The annual value of the real property, as assessed in April 1815, amounted to L.405,770 sterling.

In the year 1811, the number of freeholders entitled to vote for a county member of parliament was only 207. In 1832, the roll of these voters last made up under the old law contained 234 names, and of this number sixty-three were considered as paper voters; that is, two or three were apparent heirs of owners who were on the roll, and the remainder of the sixty-three were merely nominal owners of the estates from which they derived their privilege. The number of voters for the county member at present on the roll, under the act 2 and 3 William IV. cap. 65, is 2228.

The average size of the farms in Fife used to be about 150 acres; few of them were what might be called large, the greater number were small. Of late years, however, the tendency has been to join several together under one tenant. Many of the farmers are now men of capital and enterprise; and under their direction, supported by the liberality of the proprietors, the recent extensive agricultural improvements, which are visible throughout every part of the county, have been undertaken. The most improved implements of husbandry are everywhere in use. Thrashing-mills are to be found on most farms, some of them moved by horses, a few by wind-mills, others by water-wheels, and of late a number by steam-engines, a power which seems to be in progress of superseding all others. The farm-steadings, and the dwellings of the peasantry, have in a great measure been renewed within the last thirty years, and much improved and enlarged; and the greater part of the fields in the county are well enclosed either with stone dikes or hedges.

All the farm crops common in the south of Scotland are cultivated here upon a large scale, and almost always according to the most approved system. Flax is now seldom raised. The crops commonly cultivated are, different kinds of oats, barley, wheat, rye, beans, peas, and tares; clover and ryegrass, potatoes, and turnips; and mangel worzel has in some places been recently introduced. Farm-yard dung, the cleanings of the streets of the many towns and villages, and the sea-weed cast ashore and cut upon the rocks, are the principal manures. Lime is universally used, and marl in a few places. Bone dust has also been tried within the last few years, and, upon the whole, very successfully.

Cattle of the Fife breed have long been in high repute both as fattening and dairy stock. The prevailing colour is black; limbs short and body round; horns small, white, and turned up at the points; bone small in proportion to the carcass; and weighing, when fat, and from three to four years old, from forty to sixty stone. The cows, when well fed, yield from ten to fourteen Scotch pints of milk daily during the best of the grass season, and continue long in milk; yet, except in the neighbourhood of the considerable towns, the dairy is considered as a secondary object. The oxen were formerly much employed in labour, but they are now seldom to be seen at work. Flocks of sheep are not very numerous. The horses are much the same as in all the lowlands of Scotland. A great many pigs have of late years been reared in the county, and many of them are killed and shipped in a fresh state for the London market. Pigeons are very numerous, the pigeon-houses being lately estimated at no less than 300. Rabbits are in some places protected; and hares, pheasants, and partridges are plentiful. There are few grouse or black-cock; and fallow deer have been frequently seen at Lochfittie, Torbain, and other places.

Grain is sold in stock and sample at various weekly markets in Fife, of which the most considerable are at Anstruther, Auchtermuchty, Kirkaldy, Largo, and Newburgh. There are also weekly markets at Dunfermline, Cupar, and other places, for the same purpose; and every town of any consequence has one or two yearly fairs for the sale of cattle, &c. although it must be admitted that the number of the yearly fairs in Fife has been much diminished.

The staple manufacture of this county is linen. Dunfermline has long been famous for its extensive and almost exclusive manufacture of damasks and diapers. Of late years, by the introduction of French improvements in the machinery, and the ingenuity of the workmen, the quality of the fabrics has been much improved, and the trade greatly enlarged. Ticks, checks, sail-cloth, dowlas, and other plain linens and sheetings of every quality, are made in several towns in the county, but the great seat of the manufacture is Kirkaldy. In 1812, no less than 4,500,000 yards of linen cloth were made by the manufacturers, and stamped of the value of L.280,000; and in 1800, about 600,000 yards of plain linen were supposed to have been made by private families for their own use, which were not stamped. The number of hands employed in all the branches of this manufacture in 1800 was computed at 23,192; but the number of hands now employed is greatly increased. No part of the work of weaving in this county is at present, however, carried on with the aid of steam power. There was one steam-loom factory lately in Kirkaldy, but it has been converted into a spinning mill.

Flax has seldom or never been spun by the hand since the introduction of spinning mills. These now amount to forty-five in number, and include in all upwards of 29,000 spindles. Of these, Mr Fergus of Strathore employs at present, in his great work at Prinlaws, 2684 spindles; and erections have been made at the same work for receiving about 3000 more. Messrs C. Arthur and Sons at Kinghorn run upwards of 2000; Nelson and Co. at Kirkland 1800; Mr John Rutherford, Dunfermline, 1376; Henry Balfour and Co. Leven, 1240; Arthur Aitken and Co. Dunfermline, 1066; W. & J. Yule, Ceres, 1048; Mr Swan, Kinghorn, 1026; Mr George Moon, Russel Mill, 1012; but the various other mills have less than 1000 spindles each at work. Supposing each spindle to spin half a spyndle daily, making suitable allowances for stoppages and holidays, the various mills in Fife will spin 13,000 spyndles daily, 78,000 per week, or 3,900,000 per mill-spinner's year of fifty weeks; producing yarn to the value of L.438,750, and consuming 6500 tons of flax. The persons employed at these mills consist of hecklers, male and female preparers, spinners, reelers, &c.; and allowing one individual for each twelve spindles, there will be employed at the spinning mills in Fife, of all ages and in all the departments, about 2240 people. Messrs Nelson and Company, at the Kirkland works, manufacture a large proportion of their yarns into sail-cloth and other fabrics; and Mr Rutherford, Dunfermline, converts the greater part of his yarns into threads of all colours. The yarns at the other mills are generally sold as they are spun.

Besides the trades and manufactures of the county may be mentioned ship-building, which is carried on at Dysart, where there is a wet dock, and a Morton's slip for raising the vessels out of the water for repair; and at Burntisland, where there is a good harbour and dry dock; as also at Kirkaldy, Anstruther, and Scotscraig. There are, besides, in the county, forty-eight brewers of ale and beer, the greater part of whom also make malt; fifty-six other maltsters, six extensive distilleries, 1140 retailers of ale and spirits, about 200 retailers of foreign wines, twenty-two dealers in vinegar, 900 dealers in tea, ten manufacturers of tobacco, and about 800 dealers in that article; one soap work and eighteen tallow chandlers; two paper-mills on the water of Leven, and nine bleachfields on the same stream, four in the neighbourhood of Kirkaldy, and six in other parts of the county; ten brick and tile manufactories, and two potteries; four iron founderies, numerous smiths and wrights, ten works for tanning leather, about as many curriers, two skinners, and two glue manufacturers.

The shipping of the county is pretty extensive, and the vessels belonging to it are of such burden as to trade to all parts of the world; a number of them being engaged in the whale fisheries, and others in the Baltic, American, and Australian trade. The exports are the manufactures already mentioned, and the produce of the whale fisheries, coal, limestone, lime, potatoes, and grain of all sorts; and the imports from foreign parts are timber, bark, hides, tallow, flax, hemp, tar, iron, &c.; and coastwise, pavement and slates, groceries, and other articles required for home consumption. For the state of the harbours and the extent of their trade, see the articles FORTH and TAY.

The banking business of the county is extensive. It is managed by branches of the Bank of Scotland at Dunfermline, Kirkaldy, and St Andrews; of the Commercial Bank of Scotland at Cupar, Colinsburgh, Dunfermline, and Kirkaldy; of the National Bank of Scotland and of the Glasgow Bank at Kirkaldy; and of the British Linen Company at Cupar.

Fifeshire contains thirteen royal burghs with parliamentary privileges. St Andrews, Cupar, Anstruther Easter, Pittenweem, Crail, Kilrenny, and Anstruther Wester, with a constituency at present of 635, send one member to parliament; Kirkaldy, Dysart, Burntisland, and Kinghorn, with a constituency of 415, send another; and Dunfermline, having a constituency of 500, and Inverkeithing of thirty-eight, join with Stirling, Queensferry, and Culross in electing a member to represent them. The voters in these thirteen Fife burghs have now increased their constituency to 1588, instead of the 304 individuals who formerly composed their corporations.

The courts in the county for the trial of crime and civil suits consist, 1*st*, of the burgh courts, the magistrates of which have jurisdiction within their respective royalties or burgh territory only; 2*dly*, of the sheriff courts, for similar purposes, which are held at Dunfermline for the parishes in that presbytery, and at Cupar for the other parts of the county, at each of which towns the cases are tried either by the sheriff in person, or by substitutes, of whom he has for the purpose one constantly resident at Cupar, and another at Dunfermline, he himself being usually resident in Edinburgh; 3*dly*, of the justice of peace courts, which are held periodically at Cupar, Auchtermuchty, Anstruther, Colinsburgh, Kirkaldy, and Dunfermline, for trying actions of debt under five pounds, and petty criminal matters.

The principal jails in the county are at Dunfermline, Kirkaldy, Cupar, and St Andrews. There is also a small jail attached to the town-hall of almost every burgh in the county, but many of these are seldom used for the reception of prisoners. With the exception of the jails of Cupar, Kirkaldy, and Kinghorn, which are the best in the county, having been erected within the last twenty-five years, none of them have airing ground attached to them for the use of the prisoners, or are well fitted as places of confinement.

The great turnpike-roads of the county, which are made and maintained by the revenue of the toll-bars, and the bye-roads, which are maintained by a tax on householders, on carriages, and on each plough-gate of land, are under the charge of parliamentary trustees, consisting chiefly of the justices of the peace, and commissioners of supply for the county. Each of the four presbyteries forms a district for managing its own roads. The accounts of the turnpike trustees are printed and published annually. The accounts of the bye-road trusts have however not yet been published. The turnpike-roads and many of the bye-roads are in excellent order, great attention being paid to the introduction of the most recent improvements in road-making. Private railways of wood or iron have been used for many years in transporting for several miles the produce of the coal and lime quarries to the harbours where they are shipped. The most extensive of these railroads is that belonging to the Earl of Elgin. It proceeds from near Dunfermline to Charleston harbour, and has been lately opened to the public for the use of rail coaches carrying passengers.

Fifeshire is divided into sixty-one parishes, belonging to the four presbyteries of St Andrews, Cupar, Kirkaldy, and Dunfermline, which compose the synod of Fife; but there are four parishes besides in the presbytery of Dunfermline, and one in the presbytery of Kirkaldy, which are not situated in this county.

The population of Fifeshire in 1801 was 93,743; in 1811, 101,272, an increase of eight per cent.; in 1821, 114,550, an increase of thirteen per cent.; and in 1831, 128,800, an increase above the preceding census of twelve per cent.

FIG, or FIG-TREE. See FICUS.

FIGEAC, an arrondissement of the department of the Lot, in France, extending over 672 square miles. It is divided into eight cantons and 168 communes, containing 80,178 inhabitants. The capital is a city of the same name, situated on the river Celle, where there is some trade in corn and in wine. There are in it 1300 houses and 6452 inhabitants. Long. 1. 55. E. Lat. 44. 40. N.

FIGUERAS, a town and fortress of Spain, in the province of Catalonia, and one of the most important of its defences on the eastern frontiers of France. It is strongly fortified, and situated in the fruitful district of Ampurdan, abounding in fruits and grain, being watered by the river Fluvia, which, though usually fordable, becomes an extensive river when swollen with rain, or with the melting of the snow on the mountain whence it springs. It is in north latitude 43. 16. 1. and east longitude 3. 29. 15. from London. The fortress is capable of containing a garrison of from 12,000 to 16,000 men. The inhabitants of the town are reckoned at 4640.

FIGURAL, FIGURATE, or *Figurative*, a term applied to whatever is expressed by obscure resemblances.

FIGURE, in *Physics*, expresses the surface or terminating extremities of any body. Figures, in *Arithmetic*, are certain characters by which we denote any number which may be expressed by any combination of the nine digits. Figure, amongst divines, is used to signify the mysteries represented under certain types. Figure, in *Dancing*, denotes the several steps which the dancer makes as marking certain figures on the floor. Figure, in *Painting* and *Designing*, denotes the lines and colours which form the representation of any animal, but more particularly of the human form. Figure, in *Logic*, denotes a certain order and disposition of the middle term in any syllogism. (See LOGIC.)

FIGURE *of Speech* is defined the using a word in a sense different from what is proper to it; and the new or uncommon sense of the word is termed *the figurative sense*. Figure, in *Theology*, is used for the mysteries represented or delivered obscurely to us under certain types or actions, in the Old Testament.

FIGURE OF THE EARTH.

SECTION I.

INTRODUCTION.

The determination of the figure and dimensions of the earth is a problem of very great importance in astronomy, inasmuch as it is in reference to the earth's diameter that the distances of the planets from the sun and from each other are estimated. It is also a problem of very great interest and curiosity; and has accordingly attracted the attention of mankind since the earliest dawn of civilization.

There are two points of view under which this great question may be considered. The figure of the earth may be regarded as a fact to be determined by investigation and experience, like any other phenomenon or law of nature; in which case it is necessary to find, by the actual measurement and comparison of different portions of the terrestrial surface, the nature of its curvature, and the magnitude of its diameters. Under the second point of view, the question is one of pure theory. The earth may be regarded as a congeries of material particles, attracting each other with forces reciprocally proportional to their mutual distances, and endowed with a rotatory motion about a fixed axis; and the problem is to determine the form the whole mass would assume in virtue of the attractive and centrifugal forces by which the particles are impelled. Viewed in this light, the actual figure of the earth becomes one of the series of consequences resulting from the universal gravitation of matter, and depending on the same laws which regulate its motion in its orbit about the sun.

It would be a waste of time to inquire what were the notions of the figure of the earth which were or might have been entertained by its earliest and most ignorant inhabitants. A very slight attention to the most common phenomena renders the fact of its general roundness almost palpable to the senses. The uniform level appearance of the sensible horizon in every situation in which a spectator can be placed,—the depression of the circumpolar stars as he advances toward the south, and their elevation as he proceeds in a contrary direction,—the disappearance of a ship standing out to sea,—the projection of the earth as seen in a lunar eclipse,—and a number of other familiar appearances,—put the globular figure of our planet beyond all manner of doubt. Reasoning from such appearances, the earliest astronomers universally regarded the earth as a sphere; and their attention was solely directed, in their various measurements and computations, to ascertain its dimensions. Modern science has discovered that its figure deviates slightly from that of a sphere, being compressed or flattened at the extremities of its axis of rotation; and the object of the astronomer, at the present time, is to determine not only its dimensions, but also the exact amount of its compression.

Attempts to estimate the magnitude of the earth were made at a very early date; for Aristotle relates that the mathematicians prior to his time had found the circumference to be 400,000 stadia. But Eratosthenes appears to have been the first who entertained an accurate idea of the principles on which the determination of the figure of the earth really depends, and attempted to reduce these principles to practice. His results, in consequence of the imperfect data from which they were deduced, were very inaccurate; but his method is the same as that which is followed at the present day, depending, in fact, on the comparison of a line actually measured on the surface of the earth with the corresponding celestial arc. He had remarked, or been informed, that at Syene in Upper Egypt, on the day of the summer solstice, at noon, objects cast no shadows; whence he concluded that the sun was exactly in the zenith at mid-day. On the same day at Alexandria he observed the sun's meridional distance from the zenith to be 7° 12′, or a fiftieth part of the circumference. Then, assuming Syene to be exactly under the meridian of Alexandria (the error in this assumption was about 3°), and the distance between the two places, measured in a straight line, to be 5000 stadia, he had $5000 \times 50 = 250{,}000$ stadia for the whole circumference of the earth. It is easy to see how very imperfect this operation must have been. Without mentioning smaller errors, the neglect of the solar diameter would alone occasion an uncertainty as to the sun's declination, and consequently as to the length of the celestial arc, amounting to half a degree on the observation at Syene; and there is no reason to suppose that that at Alexandria was more exact. The terrestrial distance between the two places was assumed on equally, or probably still more loose and inaccurate determinations.

The next attempt to ascertain the dimensions of the earth was made by Posidonius. This astronomer adopted a method which differed from that of Eratosthenes only in determining the celestial arc by means of the altitude of a star, instead of the sun's zenith distance. At Rhodes the bright star Canopus, when on the meridian, barely appears above the horizon. At Alexandria the same star was observed to have a meridional altitude of a quarter of a sign, or seven and a half degrees, which, therefore, was the celestial arc intercepted between the zenith of Alexandria and Rhodes. The terrestrial distance between the two places was estimated, like that between Alexandria and Syene, at 5000 stadia, and they were both supposed to be under the same meridian. Hence, since seven and a half degrees is the forty-eighth of the circumference, we have $5000 \times 48 = 240{,}000$ stadia, for the whole circumference of the globe.

It is impossible to form any correct opinion of the degree of approximation attained in these ancient measures, as the length of the stadium is not known with any certainty. That it varied in different places, and at different times, is sufficiently obvious from the statement of Ptolemy, who, in his work on geography, assigns the length of the degree at 500 stadia, and consequently the whole circumference at 180,000, differing from the determination of Posidonius in the proportion of three to four, and still more from that of Eratosthenes. Ptolemy remarked that it was not necessary that the line measured should lie exactly in the meridian: it was sufficient to know its inclination to the meridian, or the azimuthal angle, together with the latitudes of its extreme points, in order to compare it with the meridional arc. The determination of the azimuth is, however, an operation of considerable difficulty; and Ptolemy has given no details of the method by which he proposed to estimate it. He has been equally silent in respect of the means by which the mean length of a degree was ascertained to be 500 stadia, so that the result which he has recorded is still less satisfactory than those of the two more ancient astronomers.

The active curiosity of the Arabians, which was exerted so successfully in promoting practical astronomy, did not overlook the measure of the earth. The Caliph Almamoun, who began his reign in the year 814, ordered a company of astronomers to measure a degree on the level plain of Mesopotamia. Dividing themselves into two parties, the one proceeded northward, and the other southward, in the direction of the meridian, through a degree of latitude, and measured with rods the itinerary distance as they proceeded. The perfect agreement of their conclusion with that of Ptolemy throws it open to great suspicion; and when it is considered that their operation was repeated at a different place, with exactly the same result, there can be no doubt that they blindly adopted the statement of the Greek astronomer, either from inability to execute the task assigned to them, or because they had no confidence in their own determination.

From the time of Almamoun, the problem of determining the dimensions of the earth was neglected, till the revival of astronomy with general learning in Europe. The first attempt to solve it was made by Fernel, who, about the middle of the sixteenth century, measured the distance from Paris to Amiens along the high road, by observing the number of revolutions made by his coach-wheel in the journey between these two cities. Supposing them to be under the same meridian, which is nearly true, and having ascertained the difference of their latitudes, Fernel found by this means the length of the degree to be 57,070 French toises, or about 364,960 English feet. A degree was measured long afterwards at the same place by Lacaille, in a far more adequate and scientific manner, and he found it to be 57,074 toises. This agreement is rendered less extraordinary by the circumstance that the toise of Fernel was not exactly of the same length as that of Lacaille. After all, it must be allowed that Fernel made a fortunate guess. (Delambre, *Astronomie,* tom. iii. chap. xxxv.)

But the first who had the merit of attempting to execute the geodetic operations that are indispensably necessary to effect the accurate measurement of a long line on the surface of the earth, was Willebrord Snell, a native of Holland, and a teacher of mathematics. Having established a chain of triangles between Alkmaer and Bergen-op-Zoom, and observed the angles of each triangle by means of a quadrant of five and a half feet radius, he measured a base on the frozen surface of the meadows between Leyden and the village of Soeterwoud, and determined the distance between the two places by trigonometrical computation. The length of the degree which he found was 28,500 Rynland feet, or about 55,020 toises, which is about 2050 toises too small. This result was published by Muschenbroek, who in fact revised or calculated the observations from the original papers a century after the death of Snell.

Norwood in the year 1635 attempted to measure a degree in England nearly in the same manner as Fernel. He measured the distance between London and York along the public road, taking the bearings and reducing the direction to the meridian in a rough way. The difference of latitudes he found by observations of the solstice to be 2° 28′, and thence concluded the length of the degree to be 367,176 English feet. Like the measurement of Fernel, this has been found to be a much nearer approximation than the method employed would have led us to expect.

The application of the telescope to circular instruments gave a far higher degree of precision to geodetic operations. Picard, to whom practical astronomy is indebted for this capital improvement, was the first who measured an arc of the meridian with such precautions and care as the delicate nature of the operation requires. With a standard scale he measured a base of about six English miles in length; and observed the angles of his triangles with a quadrant, having a telescope adapted to it with cross wires in its focus. He even calculated the error produced by the instrument being placed out of the centre of the station, and determined the zenith distance of a star in the constellation Cassiopeia with a sector, for the purpose of obtaining the differences of latitude. The distance between Amiens and Malvoisine was found to be 78,850 toises, and the difference of latitude 1° 22′ 55″, whence the result gave for the degree at Amiens 57,060 toises; but as the aberration and nutation were unknown at that time, and the refraction was not taken into account,—causes of error to which it is indispensably necessary to have regard,—a determination which agrees so nearly with the results of recent measures could only have arisen from a fortunate compensation of errors. In fact, his toise was somewhat shorter than that which has since been adopted as the standard; and the error occasioned by this circumstance nearly compensated that which was committed in determining the celestial arc, so that in recalculating all the observations, the degree is found to be very nearly the same as was found by Picard.

Hitherto geodetic operations had been confined to the determination of the magnitude of the earth; but a discovery made by Richer turned the attention of mathematicians to its deviation from the spherical form. This astronomer having been sent, by the Academy of Sciences of Paris, to the island of Cayenne in South America, for the purpose of determining the amount of terrestrial refraction, and other astronomical objects, observed that his clock, which had been regulated at Paris to beat seconds, lost about two minutes and a half daily at Cayenne, and that, in order to bring it to measure mean solar time, it was necessary to shorten the pendulum by more than a line. This fact, which appeared exceedingly curious, and was scarcely credited till it had been confirmed by the subsequent observations of Varin and Deshayes, was first explained in the third book of the Principia, by Newton, who showed that it could only be referred to a diminution of gravity arising from one of two causes—a protuberance of the equatorial parts of the earth, and consequent increase of the distance from the centre, or from the counteracting effect of the centrifugal force, occasioned by the rotation of the earth. The former could not, on any reasonable supposition regarding the figure of the earth, be regarded as adequate to produce the effect; but the latter, which would produce a retardation of the pendulum at Cayenne in the ratio of the square of the sine of 6° to that of 49° (the respective latitudes of Cayenne and Paris), might amount to 1·46 seconds. This was the first direct proof that had been obtained of the diurnal rotation of the earth.

From this time the exact determination of the figure of the earth began to assume a degree of importance which had not formerly attached to it. The centrifugal force arising from the diurnal rotation completely set aside the idea of perfect sphericity. Newton, assuming that the earth had been originally fluid, and supposing its density to be the same throughout the whole mass, and supposing moreover that its constituent molecules attract one another in proportion to the inverse square of the distance, demonstrated that it would assume, in consequence of the rotation, the form of a spheroid flattened at the poles; and that the proportion of its equatorial to its polar axis would be 230 to 231. But the supposition of the equal density of the earth is obviously very improbable, and consequently the ratio of the equatorial and polar diameters must be different from that now mentioned. Newton erroneously concluded that if the density is greater in the interior of the earth than at the centre, the compression would be greater than in the case of a spheroid of equal density. This mistake was pointed out by Huygens, who, in order to determine the amount of the compression from theory, reasoned in this way. Suppose two tubes to be united at the centre of the earth, forming a right angle with each other at that point, and extending to the surface, one in the plane of the equator, and the other along the polar axis, and filled with a homogeneous fluid. Now the fluid contained in the polar branch exerts a pressure on the centre equal to the whole of its weight, while the pressure of that in the other tube will be diminished by the centrifugal force. The second column, therefore, if of the same length, will be less heavy than the first; and in order to restore the equilibrium, it is necessary that the equatorial tube shall have gained as much in length as it has lost in weight through the effect of rotation. Hence the sea in the equatorial regions must be higher, or at a greater distance from the centre, than the polar sea, and consequently the earth must have a flattened form. Calculating from the supposition that the density increases regularly from the surface to the centre, where it is infinite, Huygens found the ratio of the diameters to be that of 578 to 579. This investigation is given in his work *De Causa Gravitatis*, published in 1690.

The theoretical determinations of the form of the earth by Newton and Huygens were at variance with the results of geodetic operations that had been carried on in France under the superintendence of the first Cassini, from 1680 till 1716, for the purpose of making a geometrical survey of that country. Cassini found the degree of the meridian to the south of Paris to be 57,092 toises, while on the north of that city it was only 56,960 toises. This result led to the conclusion that the earth is a protracted spheroid, or elongated at the poles; a conclusion entirely inconsistent with the principles of hydrostatic equilibrium, and the deductions of Newton and Huygens. The question, however, was of too great importance to astronomy to be allowed to remain undecided. Accordingly, the Academy of Sciences of Paris determined to apply a decisive test, by the measurement of arcs at a great distance from each other. For this purpose some of the most distinguished members of their body undertook the measurement of two meridional arcs, one in the neighbourhood of the equator, and the other in a high latitude. In 1735 Godin, Bouguer, and La Condamine, proceeded to Peru, where they were joined by two Spanish officers, Don Georges Juan and Antonio d'Ulloa, and, after ten years of laborious exertion, they measured an arc of above three degrees, between the parallels of 2′ north and 3° 4′ 32″ south latitude. The other party, consisting of Maupertuis, Clairaut, Camus, Lemonnier, Outhier, and Celsius, were in some respects more fortunate, inasmuch as they completed the measurement of an arc near the polar circle, of 57 minutes, and returned to Europe within sixteen months from the period of their departure.

The measurement of Bouguer was executed with great care; and, on account of the locality (the extremities being on different sides of the equator), as well as the excellent manner in which all the details were conducted, it has always been regarded as a most valuable determination. The original base was measured twice, and the difference between the two measures was scarcely two and a half inches. A second base of 5259 toises was measured with the most scrupulous attention by Bouguer, Condamine, and Ulloa, near the southern extremity of the arc, and the result differed less than a toise from the length calculated from the triangles. The latitudes at the two extremities of the arc were determined by simultaneous observations of the same star with zenith sectors. In fact, as the nutation of the earth's axis was then unknown, and as a considerable time necessarily elapsed before a large instrument could be transported from one extremity of the arc to the other, the results of successive observations with a single instrument presented little accordance. By the simultaneous observations, the greatest deviation from the mean did not exceed three or four seconds.

In consequence of a misunderstanding that unhappily sprung up among the principal persons engaged in this memorable expedition, their operations were conducted separately, and we have accordingly three independent results, but all agreeing very nearly with each other. The first is that of Bouguer, who found, after the various reductions, the length of the degree of the meridian at the equator, and reduced to the level of the sea, to be 56,753 toises. Condamine found 56,749 toises, and the Spanish officers 56,768 toises.

The party of Maupertuis, though their labours were sooner completed, had also to contend with very great difficulties. At their departure from France they had hoped to find a sufficient number of stations among the small islands situated in the Gulf of Bothnia; but on their arrival it was found impracticable to carry on a triangulation among the islands, consequently they were obliged to penetrate into the forests of Lapland. They commenced their operations at Tornea, a city situated on the mainland near the extremity of the gulf, and which formed the southern extremity of their arc. From this place they carried a chain of triangles northward to the mountain of Kittis, lat. 65° 51′. Here they commenced the observations of latitude by observing the distance of their zenith from the star δ Draconis; and having obtained a sufficient number of observations, they returned to Tornea, to determine the latitude of their station there in the same manner. At Tornea they observed not only the star δ Draconis, but also α Draconis; and some doubt having arisen respecting the accuracy of the determination at Kittis, they again repaired to that station, to observe the last star there also. The amplitude of the celestial arc was found, by taking the mean of the observations, to be 57′ 29″·6.

It now remained only to measure a base, and thereby determine the terrestrial distance between Tornea and Kittis. This was accomplished on the frozen surface of the river, by two parties who measured separately, and the difference between their results amounted only to about four inches. From this it resulted that the terrestrial arc between Tornea and Kittis was 55,023 toises, giving 57,437 toises to the degree, and consequently exceeding the degree measured by Picard in France by 337 toises.

As all these determinations concurred in proving that the degrees of the meridian increase very sensibly in length from the equator to the high latitudes, no doubt could any longer be entertained that the earth is compressed at the poles. The operations of the two Cassinis in France alone gave results leading to an opposite conclusion; and it therefore became desirable to ascertain the cause of the anomaly. For this purpose Maupertuis and his former associates undertook the verification of Picard's operations; and it resulted from the remeasurement of the arc between Paris and Amiens that the degree was equal to 57,183 toises. But a more extensive series of operations was undertaken some time after by Cassini de Thury (the third of that name) and Lacaille. With a view to determine more accurately the variation of the degree along the French meridian, they divided the whole arc between Dunkirk and Collioure into four partial arcs, embracing about 2° each, by observing the latitudes at five different stations. While engaged in this measurement, they discovered that the toise which had been used by Picard was shorter by about a thousandth part of the whole than that which formed their standard, and that his final results were accordingly too great by about a thousandth part. They also found the mean length of a degree between Paris and Bourges to be 57,071 toises; between Bourges and Rhodez only 57,040 toises; and between Rhodez and Perpignan 57,048 toises; thus showing on the whole a very sensible diminution as we proceed towards the south. The last portion which they examined was that between Paris and Dunkirk; and after a very careful determination of the latitudes, and the measurement of a base of verification near Dunkirk, they found the degree to be 57,074 toises, greater than any of the former, as ought to be the case on the hypothesis of a polar compression.

Another important operation was likewise undertaken by Cassini and Lacaille, namely, the measurement of a degree of a parallel of latitude. The place they selected was near the mouths of the Rhone, under the forty-third parallel. One of the observers took his station on the mountain Sainte Victoire, near Aix, and the other on Saint Clair, near Cette. On the tower of the church of Sainte Marie, a village situated between the two stations, a signal was made by firing a quantity of loose gunpowder; and the instant of the flash was noted by each of the observers. The difference of sidereal time thus determined was 7 minutes 33·25 seconds, corresponding to a difference of meridians of 1° 53′ 19″. The distance between the two stations, which was ascertained by triangulation, being reduced to the distance on the parallel intercepted between the two meridians (at the latitude of 43°), was found to be 78,663 toises, whence the length of the degree was computed to be 41,651 toises. This exceeded by about 250 toises the length of a degree of the same parallel computed on the hypothesis of the earth's being a perfect sphere. The details of all these operations are given in the *Meridienne de Paris Vérifiée*.

About the middle of the last century several arcs of meridian were measured in various countries, which, though of inferior importance in comparison of the more extensive surveys which have since been undertaken, are nevertheless deserving of enumeration. In 1751 Lacaille measured an arc at the Cape of Good Hope, whither he had gone for the purpose of determining the lunar parallax, and making other astronomical observations. At the latitude of 38° 18½′ he found the degree of the meridian to be 57,037 toises. This result was nearly the same as had been obtained in France, 10° farther from the equator; and clearly proved either the existence of great local irregularities in the form of the earth, or the dissimilarity of the two terrestrial hemispheres. Considerable disposition has been manifested by later observers to question the accuracy of this result; fortunately the details of the operations have been preserved, and, on a careful investigation of them by Delambre, no error of any importance was found either in the methods or the calculations. If there is any considerable inaccuracy, it must have proceeded from the use of inadequate instruments. But, after making all reasonable allowance for this cause of error, the Cape degree still continues to appear anomalous; and it would be desirable to have the whole of Lacaille's arc re-measured.

In 1751 the measurement of a terrestrial arc was undertaken in the Roman states by the Jesuits Maire and Boscovich. It extended nearly two degrees, between Rome and Rimini, and it was found that the degree of meridian between these parallels, namely, 42° and 44°, contained 56,973 toises. The details are given at length by Boscovich, in a work of great elegance, and entitled *De Litteraria Expeditione per Pontificiam ditionem*, &c. Romæ, 1755.

Liesganig, a Jesuit, in 1762 also executed two measures of a meridional degree, one in Hungary and the other in the Austrian states; but it has been shown by Baron Zach, in his *Correspondence Astronomique*, vol. vii. that the results merit no confidence, and, in fact, would lead to certain error if employed as elements in determining the figure of the earth.

About the same time, in 1764, an arc of meridian was measured in North America, on the peninsula between the Chesapeake and Delaware bays, by two Englishmen, Charles Mason and Jeremiah Dixon. They employed no triangulation, but measured the line with deal rods along the whole extent of the arc, the mean latitude of which was 39° 12′. Their rods were afterwards compared with the five-feet brass rods made by Bird. The latitudes were determined with a zenith sector. The length of the degree, after the necessary corrections and reductions were made, was found to be 60,625 English fathoms, or 56,888 toises. There is no doubt that great care was bestowed on this operation; it is, however, easy to see that the measurement of so long a line by means of rods is liable to many causes of error from which the method of triangulation is exempt.

In 1777 Beccaria undertook to measure a degree in the plains of Piedmont. He found the degree of the meridian at the latitude of 44° 44′ to contain 57,024 toises; but great uncertainty remained respecting the correctness of the latitudes, the extreme points of the arc being in the near neighbourhood of immense ranges of mountains, which could not fail to produce a very considerable deviation of the plumb line. It was supposed that as both ends of the arc were terminated by mountain ranges, whereas Boscovich's arc had been carried across the Appennines and terminated at the sea coast, the errors of the two measures occasioned by the local attraction, being of opposite kinds, would neutralize each other, and give a correct mean result.

Amidst the rapid advances of mathematical science towards the end of last century, the determination of the figure of the earth was not overlooked. In the year 1785 a memorial was presented to the British government by Cassini de Thury, stating the important advantages that would result to astronomy and navigation, from having the difference of longitude of the Greenwich and Paris observatories determined by a geodetic measurement. Fortunately this proposal was agreed to. The English operations were placed under the superintendence of General Roy, who to active and indefatigable zeal united great skill and experience in practical astronomy and surveying. In the summer of 1784 a base of rather more than five miles was measured on Hounslow Heath. In the measurement of this base, deal rods were at first employed; but as these were found to warp, and be affected with the variations of the hygrometrical state of the atmosphere, glass tubes were substituted; and in 1791 the same base was measured with a steel chain carefully made by Ramsden, yet the difference from the former measure was found to be only three inches. The mean result was 27,404·2 feet reduced to the level of the sea, and the scale being taken at the temperature of 62° of Fahrenheit. A chain of 32 triangles, in connection with this base, extended over the country to Dover and Hastings; and two more, stretching across the channel, connected them with the French signals on the opposite side. The instruments employed in this survey were of the most excellent description, and far superior to any that had ever been employed in similar operations. The angles of each triangle were measured by a large theodolite constructed by Ramsden; and it was this splendid instrument that first exhibited the *spherical excess*, or the minute quantity by which, on account of the sphericity of the earth, the sum of the three angles of a triangle on the earth's surface exceeds 180°.

The French part of this great operation was conducted with equal ability by Cassini (the fourth of that name), Mechain, and Delambre. The angles were measured with the repeating circle of Borda; an instrument of a very different description from the theodolite, but which in geodetic operations may fairly be allowed to give, if not equally, at least sufficiently correct results, while in practice it is much more commodious. The result of the combined measures showed the meridian of Paris to be 2° 19′ 51″ east of Greenwich, or 9″ less than had been determined by Dr Maskelyne.

Soon after this time a series of geodetic measurements was commenced both in France and England, which, in point of extent, as well as minute accuracy, far surpassed all the operations which had yet been undertaken with a view to determine the figure of the earth. In 1791 the National Convention of France having agreed to remodel the system of weights and measures, determined to adopt a standard taken from nature, which might be universally applicable in all countries, and capable of being restored in any future age, if by accident it should happen to be lost. Two such standards were proposed,—namely, the length of the pendulum, which makes a given number of vibrations in a given latitude; and the quadrant of the terrestrial meridian. Of these the pendulum is by far the most easy to be determined; but it was objected, that as the length of the pendulum varies at different latitudes, and also depends in some degree on the geological character of the country where it is measured, its length, if it should happen to be lost, could not be recovered, without knowing the precise place at which it had formerly been determined. The length of the quadrant of the meridian is, however, invariable, and, if the earth is a regular spheroid of revolution, must be the same at all places. Accordingly, the Convention chose the ten millionth part of the meridian from the equator to the pole as the unit of their new scale; and in order that this unit might be determined with the greatest possible precision, it was resolved to remeasure the arc of the meridian of Paris, and to extend it from Dunkirk to Barcelona, a distance comprehending altogether an arc of about nine degrees. The practical execution of this undertaking was confided to two astronomers of distinguished ability, Delambre and Mechain, by whom the requisite operations were carried on during the years 1792, 1793, and 1794, amidst all the dangers and difficulties arising from the disorganized state of the country, with a resolution and courage of which the annals of science afford few examples. The triangles amounted to 115 in number. Each of the three angles of every triangle was separately observed with the repeating circle. The different observations, with the original registers and remarks of the observers, were compared by commissioners, among whom were some of the ablest men in France. A form was drawn up, after which all the calculations were made. The calculations of the triangles, as well as of the azimuths, were examined by Tralles, Van Swinden, Legendre, and Delambre himself. The triangles were connected in the neighbourhood of Paris with a base of upwards of seven miles in length, being 6075·9 toises, at the temperature of 16¼ centigrade, or 61¼ of Fahrenheit. A base of verification of 6006·25 toises was measured by Mechain, near Perpignan, at the southern extremity of the arc; and the measured length was found to differ by less than a foot from the length deduced by calculation from the first base, though the distance was more than 436 miles. A line of this length, measured with extreme precision, is obviously quite sufficient to enable us to infer, with all the requisite exactness, the length of the quadrantal arc; but the French astronomers resolved to extend the triangulation still farther. Accordingly, Mechain repaired again to Spain, and in the year 1805 continued the chain of triangles from Barcelona to Tortosa, on the coast of the Mediterranean. At this place his labours were prematurely terminated by an epidemic fever. The prolongation of the arc was, however, committed to two philosophers of distinguished reputation, Biot and Arago. An immense triangle, one of the sides of which exceeded 100 miles, connected the coast of Valentia with the small island of Formentera, the most southerly of the Balearic group, and distant no less than 12° 22′ 13″·39 from Dunkirk, the northern extremity of the arc. The result of the whole gave a value of the quadrantal arc, differing somewhat from that determined by Delambre and Mechain, but so little that the length of the toise would be scarcely affected by four times the millionth part of itself. The details of this magnificent operation are given at length in the four volumes of the *Base Metrique.*

The English survey, which had been interrupted by the death of General Roy in 1790, was resumed in 1793 under the direction of Colonel Mudge. The original triangles between Greenwich and Dover were extended along the coast to Dunnose in the Isle of Wight, and thence through Devonshire and Wiltshire, and connected with a base of verification measured on Salisbury Plain. The length of this base was found, after the proper reductions, to be 36574·4 feet, differing scarcely one inch from the length deduced by calculation from the base on Hounslow Heath. So near a coincidence, though probably owing in some degree to a compensation of errors, affords a convincing proof of the extreme accuracy with which every part of the operation had been conducted. In 1802 the triangulation was carried into Yorkshire, and a meridian arc measured from Dunnose to Clifton. The latitudes at the terminal points were determined with Ramsden's zenith sector. The arc was afterwards extended to Burleigh Moor, comprehending nearly four degrees. It may be remarked, that both the French and English arcs present this singular anomaly, that when portions of them, at particular places, are considered separately, the length of the degree appears to increase on going southward.

The survey has been continued, with occasional interruptions, up to the present time, under the able direction of Lieutenant-Colonel Colby; and the triangulation has been carried to the remotest parts of Scotland, and over a considerable part of Ireland. In the course of the operations, several important improvements, both in respect of the instruments employed, and in the method of conducting geodetic measurements in general, have been introduced into practice. A base of upwards of seven miles has been measured near Londonderry; and it now only remains to determine the latitudes of some stations, to give us the elements of a new and greatly prolonged arc.

In the years 1801, 1802, and 1803, Maupertuis' Swedish arc was re-measured by Svanberg, and extended nearly 40′ to the south. The methods were the same as had been employed by Delambre. The extremities of the new arc were at Mallörn and Pahtawara. The distance was found to be 92,778 toises, and the difference of the latitudes 1° 37′ 20″·3; whence 1° = 57,196 toises. This agrees much better than the result of Maupertuis (57,422 toises) with other measures; but the difference, which implies an error of 12″ in the latitude of Kittis as determined by the French academicians, has not been satisfactorily accounted for; so that there is still some doubt about the length of the degree in that latitude. (See Svanberg's *Exposition des Operations faites en Laponie,* &c. Stockholm, 1805.)

Since the beginning of the present century, two arcs of

Figure of the Earth.

f meridian have been surveyed in India. The first was in n the neighbourhood of Madras, and comprehended only 1° 35′. The second, however, is the longest which has yet been measured. The first, and a large part of the second, was accomplished under the direction of Colonel Lambton; and the instruments and methods of observation and calculation were exactly the same as those that had been employed by Colonel Mudge in the English survey. The southern extremity of the second arc was at Punnæ, near Cape Comorin, latitude 8° 9′ 32″·51; and the northern at Daumergidda, latitude 18° 3′ 16″·07. The amplitude is consequently 9° 53′ 43″·56, and the distance between the extremities was found to be 598,629·98 fathoms (about 680 miles), giving 60,495 fathoms, or 362,970 feet, for the length of the degree. Several bases were measured, and the whole of the operations appear to have been conducted with great skill and accuracy. This arc has since been extended by Captain Everest to Kulliampoor, latitude 24° 7′ 11″·8; so that the whole length now includes very nearly sixteen degrees. The details of Colonel Lambton's operations are given in the different volumes of the *Asiatic Researches* (see vols. viii. x. xii.), and those of Captain Everest, in his "*Account of the Measurement of an Arc of the Meridian between the Parallels of* 18° 3′ *and* 24° 7′," printed at the expense of the East India Company, but not yet published.

Various geodetic operations on a less extensive scale have been recently executed, which are better adapted, perhaps, to give information respecting the local curvature than the general form of the earth. Beccaria's arc has been remeasured by Plana and Carlini: the results clearly demonstrate the existence of some errors in the original measurement, but they are not yet altogether satisfactory, and the country is very unfavourable. The distance between Göttingen and Altona has been measured by Gauss; and the amplitude of the corresponding celestial arc is known with the utmost precision, from observations of the latitude made at the respective observatories of the two places. The amplitude, however, is only about two degrees, and there is some doubt about the exact length of the iron bars with which the base was measured. A more extensive arc has been measured in Russia by Struve. It extends at present to three and a half degrees, and it is understood that it is in contemplation to prolong it still farther. Many new methods have been employed in this measurement; and it acquires additional value from its high latitude, and the acknowledged skill and accuracy of the observer.

The above are the principal arcs of meridian, but some arcs of parallel have also been measured. Theoretically speaking, the figure of the earth may be determined from the measurement of arcs of parallel, as readily as from meridional arcs; and the geodetical operations in the one case differ in no respect from those in the other. But the great, and, we fear, insurmountable difficulty, is to determine with sufficient precision the difference of astronomical longitudes. In a subsequent part of this article we shall have again occasion to mention Cassini's measurement of an arc of parallel across the mouth of the Rhone; of the English arc between Beachy Head and Dunnose; and that recently made from Marennes to Padua.

The problem of determining the earth's figure from the laws of hydrostatic equilibrium has not yet received the complete solution which the present advanced state of analytical science might lead us to expect. We have already mentioned the results found by Newton and Huygens. Maclaurin first demonstrated that the ellipsoid f revolution is a figure which satisfies the conditions of quilibrium in the case of a revolving homogeneous body, whose particles attract one another according to the law of the inverse square of the distance; and he moreover determined the amount of the attraction in a particle situated anywhere on the surface of such a body. This was an important step towards the solution of the problem. A few years afterwards, Clairaut published his *Théorie de la Figure de la Terre*, which, among other results, demonstrated with uncommon elegance, contained a very remarkable theorem which establishes a relation between the oblateness of the earth and the variations of gravity at different points of its surface, and consequently gives the means of determining the earth's figure by means of observations of the length of the seconds pendulum at different latitudes. Maclaurin's discovery gave the intensity of the gravitating force on the surface of the spheroid, or in its interior; but it was necessary to assign the force with which an exterior point is attracted. This was partly accomplished by D'Alembert, who proved that the attraction of any ellipsoid whatever upon a point situated in the prolongation of one of its axes, is to the attraction of a similar spheroid having the same centre, and passing through the attracted point, as the mass of the first spheroid is to the mass of the second. Legendre found an approximate expression by means of series, for the attraction on a point placed anywhere without a spheroid of revolution; and Laplace extended the solution to ellipsoids in general. But the complete solution was reserved for Mr Ivory, who obtained in finite terms a very simple expression for the attractive force of an ellipsoid on an exterior point, and thereby completed the theory of Maclaurin. It may be stated in a general way, that notwithstanding all the researches that have been made respecting this very intricate subject, the only positive results which theory has yet supplied are the three following:—1*st*, Maclaurin's demonstration that a homogeneous mass revolving about an axis will be in equilibrio with the figure of an ellipsoid of revolution; 2*d*, Clairaut's theorem for determining the ellipticity by means of pendulum observations; and, 3*d*, the expression for the attraction of ellipsoids on exterior particles, found by Mr Ivory. A complete theory would determine whether there are or are not other figures besides the ellipsoid, under which the equilibrium could subsist; but this has not yet been accomplished. Indeed it has not even been proved that the sphere is the only figure which could be assumed by a body at perfect rest, and whose molecules are subjected to no other forces than their mutual attractions.

Our limits do not permit us to enter into details respecting the numerous experiments that have been made of late years to determine the figure of the earth by measuring the variations of gravity at different places by means of the pendulum. The most valuable series of observations of this kind we yet possess are those of Captain Foster, reduced under the direction of Mr Baily, and published in the *Memoirs of the Royal Astronomical Society*, vol. vii. But a discovery recently made by Bessel proves that less accuracy has been obtained by this method than was supposed. It has been found, that a pendulum, when vibrating, drags along with it a portion of air, the precise effect of which can be ascertained in no other way than by actual experiment in vacuo with each individual pendulum. The probable correction which it would be necessary to apply to the results that have already been found, cannot be satisfactorily determined.

The mean of the pendulum experiments gives rather a higher value of the ellipticity than the results of geodetic measures; but there are many elements, particularly the irregular constitution of the exterior crust of the earth, and the density of the strata surrounding the station, which can scarcely be determined, and which yet affect materially the results of the experiments. This subject will be resumed under the article Pendulum.

Besides the methods which have now been alluded to, physical astronomy furnishes other means of arriving at a knowledge of the figure of the earth. The precession of the equinoxes, and nutation of the earth's axis, are phenomena depending on the compression of the earth; and as their amount is now ascertained, from astronomical observations, with the utmost accuracy, we can reciprocally deduce from them a knowledge of the compression. They do not, however, give us an absolute value of the amount of compression, but they make known the limits within which it must necessarily be confined. These limits are $\frac{1}{279}$ and $\frac{1}{378}$. But a more delicate measure of the same element is furnished by some irregularities in the moon's motion to which it gives rise; and as the lunar theory has now attained a very high state of perfection, and as the small irregularities which cause so much perplexity in geodetical measures here entirely disappear, this is perhaps the most satisfactory method of all of determining the ellipticity of the earth. The equations into which the irregularity in question enters were discovered by Laplace; and the ellipticity necessary to produce the observed effect was found, on calculation, to be $\frac{1}{304}$; confirming in a most remarkable manner the deductions from the measurement of arcs and the observations of the pendulum.

SECTION II.

OF THE MEASUREMENT OF TERRESTRIAL ARCS.

The determination of the figure of the earth, being founded on the comparison of lines actually measured on its surface with the corresponding arcs of the celestial sphere, requires a combination of geodetical and astronomical operations, which it will be our object in the present section to explain. Theoretically considered, the geodetical line to be measured may lie in any direction, because it can always be reduced to the meridian or to any other given direction; but, for practical reasons, which will be pointed out hereafter, it ought to be taken, as nearly as the nature of the country in which the measurement is made will permit, either in the direction of the meridian, or of a parallel of latitude. Differences of latitude, however, can be determined with greater precision than differences of longitude; the meridional arcs are consequently the best adapted to the purpose. Satisfactory results can only be obtained from the measurement of lines of very considerable length, for example, of several degrees; and this circumstance renders the geodetical operations both laborious and complicated. In no place of the world, probably, and certainly in no populous country, could it be possible to find a territory so free from obstructions as to admit of the direct measurement of a line of two or three hundred miles in the same direction. Hence, when an operation of this nature is to be undertaken, the country in which the direction of the line to be measured lies is divided into triangles; the angles of each triangle are accurately observed with a theodolite, or some other equivalent instrument; and the side of one of them being actually measured, all the other sides are computed from it by the rules of trigonometry. In this manner the length of the whole line is ascertained, and on comparing it with the celestial arc, the data are obtained for deducing the dimensions and form of the earth.

It appears, then, that in order to determine the figure of the earth by the measurement of degrees, four distinct sets of operations are necessary: 1*st*, The measurement of one side of a triangle, or of *the base* as it is called; 2*d*, the observation of the angles of each triangle, together with the height of the station, in order that the triangles may be reduced, if necessary, to the horizontal plane, and to the level of the sea; 3*d*, the observation of the *azimuths* of the sides of the triangles, or the angles they make with the meridional line; 4*th*, the latitudes of the extreme points of the line. It is immaterial in what order these operations are undertaken. We shall begin with the measurement of the base.

The length of the base must be regulated in some degree by the nature of the locality; but being the fundamental element from which the sides of all the triangles are deduced, it should not be less than five or six miles. A piece of ground must therefore be selected, as nearly level as possible, and admitting a line of that length to be described on it. The direction of the base is first marked out by pickets; and, in order to place these in the same straight line, or rather in the same vertical plane, a telescope, mounted in the manner of a transit instrument, is set up at one extremity, by means of which the observer is enabled to direct an assistant, by signals, to the exact position in which the picket is to be placed, and also to bring their tops exactly into the same level. As a farther guide, a rope may then be stretched between the pickets; and, for greater security in the subsequent operations, the whole extent may be approximately measured by rods or chains, in the usual manner. The extremities of the base ought to be permanently marked by points. The centres of metal tubes, cannon for example, let into the ground to a considerable depth, answer this purpose very conveniently.

These preliminary operations being accomplished, the next step is to proceed to the more delicate operation of measuring the exact distance between the terminal points, or extremities of the base.

Various methods have been practised for this purpose. In the measurement of the first base of the trigonometrical survey on Hounslow Heath by General Roy, deal rods were at first employed, as had been done by Lacaille, Lemonnier, and others; but though every precaution was used in selecting the best seasoned timber, and every means employed to secure the rods from flexure, it was discovered, in the course of the operations, that they were liable, from variations in the state of the atmosphere as to moisture or dryness, to sudden and irregular changes of such magnitude as to destroy all confidence in the results. They were therefore laid aside; and glass rods, consisting of straight tubes twenty feet in length, and about an inch in diameter, and enclosed in wooden cases, were substituted. The only alteration to which these were subject arose from the expansion and contraction from variations of temperature; and as such alterations follow constant and ascertainable laws, their effects could be easily computed, and a correction made for them. But the apparatus ultimately adopted, both in the measurement of this base, and the other bases subsequently measured for the purpose of verifying the operations in the English survey, consisted of two steel chains, made with great care by Ramsden, of a hundred feet in length, and composed each of forty links, joined in the manner of a watch chain. The chains were supported by deal coffers, and after being placed in a straight line, were stretched with a weight of fifty-six pounds. Their temperature and inclination to the horizon were carefully noted at the same time, and the proper corrections subsequently made.

This method has been objected to, on account of the uncertainty of giving the chain always the same degree of tension, and of the rubbing and wear of the joints; but the best proof of the accuracy of the results obtained by it consists in the fact, that the two measurements of the base on Hounslow Heath, first by glass rods, and secondly by the steel chains, differed from each other, after all the reductions were made, by less than three inches, although the whole length exceeded five miles. For an account of the comparison of the chains with one another, and with the standard brass yard made by Ramsden, we must refer to the *Philosophical Transactions*, vol. i.

The use of chains has been confined to the English and Indian surveys. Bouguer, in the Peruvian measurement, employed an iron rod of about a toise in length, which, from the frequent comparisons that have since been made of it with other standards, has been particularised by the name of toise of Peru. For the determination of the meridian of Dunkirk, Borda employed rules of platina, exactly two toises in length, and furnished with a very ingenious contrivance for ascertaining the expansion. Along one side of the rule there was a slip of brass, firmly fixed at one extremity, but at liberty to move along the rule at the other end, according to the relative expansion of the two metals. The relative expansion being read off by means of a micrometer, gave a ready means of computing, from tables previously constructed, the absolute expansion of the platina rule. Four rules were made use of, three of which were always placed on the ground at once; and in order to prevent any derangement, they were not brought into absolute contact. A small interval of a few millimetres was left between them, which was measured by means of a slider attached to the preceding end of each rule, and which was pushed out till it came into contact with the following end of the preceding rule. See Delambre, *Astronomie*, tome iii. p. 538, or *Base du Systême Metrique*.

Various other contrivances have been used for the measurement of the base line. MM. Plana and Carlini, in the re-measurement of Beccaria's arc, employed measuring rods of wood, twelve metres in length, of the form of hollow parallelepipeds. For the Hanoverian base measure, between Altona and Gottingen, Gauss employed three rods of hammered iron, each twelve French feet in length. But the most ingenious apparatus which has yet been invented for this purpose, is that which was made by our celebrated artist Troughton for the Irish base. As this instrument is probably destined to supersede all others previously used, we shall briefly describe the principle on which it is constructed.

Let AB and DE (Plate CCXLIV. fig. 1) represent two bars of different metals, firmly united to a transverse bar at the middle C, but entirely free to move independently of each other at the extremities, according to their different expansions. AP and BQ are two tongues of steel attached to the extremities of the two rods AD and BE, by double conical joints, around which they are capable of making a small angle with the lines perpendicular to AB or DE. At a certain given temperature the bars are exactly of the same length, when, consequently, AP and BQ are parallel to each other, and perpendicular to the bars. Let us now conceive the bars to receive an increase of temperature, and that the dilatation of AB is greater than that of DE. In consequence of the increased temperature, both bars will be lengthened, but their lengths will no longer be equal; consequently the two tongues AP and BQ will no longer be parallel; for, suppose AB to become *ab*, and DE to become *de*, then AB being by hypothesis a more expansive metal than DE, *ab* will be longer than *de*, and the steel tongues will take the positions *ax* and *by*, inclined to each other. But if the point P is taken at such a distance from the bars that PA is to PD in the ratio of the dilatation of AB to DE, then in the new position *ax*, the point P will not sensibly deviate from the perpendicular AP, at least for moderate variations of temperature. In the same manner, the point Q will not sensibly deviate from its first position in the perpendicular BQ, so that the distance between P and Q remains sensibly the same. It is easy, however, to see that the dilatation of the bars must be confined within narrow limits; for, as the length of the tongue is invariable, P will not be found exactly in the line AP after the expansion has taken place; it will be on the same side of AP on which are the points *a* and *d*, and its distance from AP will be accurately measured by the quantity AP × (tan. APa — sin. APa); and as the same thing takes place with regard to Q, the distance between P and Q will be increased by twice this quantity. But as the angle APa must in all cases be extremely small, the difference between its tangent and its sine is altogether inappreciable. It is unnecessary to remark, that the same consequences (*mutatis mutandis*) take place when the temperature falls below the assumed standard.

In the instruments made use of in the measurement of the Irish base, the bar AB was of brass, and DE of iron. The length of each was ten feet, and the distance between them two inches. The length of the tongue is hence easily found from the relative dilatation of the two metals. Suppose the expansion of brass to be to that of iron in the ratio of 83 to 53 for an increase of 1° of temperature, and let PD $= x$ inches, we shall have $x : x + 2 = 53 : 83$; whence $x = \frac{53}{15} = 3\frac{1}{2}$ inches very nearly. But the precise position of the points P and Q must be determined by actual experiment: for the expansion or contraction of no two bars, even of the same metal, are ever found to be exactly the same.

In practice, five or six sets of bars, constructed in the manner now described, and placed in strong deal boxes supported on trestles, are laid along the line to be measured, and accurately levelled. They are placed at a small distance from each other, and the distance between the dots on the adjacent steel tongues of two succeeding bars is accurately measured by an ingenious micrometrical apparatus constructed so as to form a compensating instrument of exactly the same nature as the measuring bars.

The conception of this elegant apparatus belongs to Lieutenant-Colonel Colby; and the practical results it gives correspond with its theoretical excellence. It is computed that the greatest possible error of the base measured on the eastern shore of Lough Foyle, in the county of Londonderry, cannot exceed two inches, though the length is very nearly eight miles.

The reduction to the level of the sea is made as follows: Let $r =$ radius of earth, $x =$ height above the level of the sea, $a =$ measured length of the base, and $a' =$ its reduced length; then

$$a' = a\left(\frac{r}{r+x}\right) = a\left(\frac{1}{1+\frac{x}{r}}\right) = a\left\{1 - \frac{x}{r} + \left(\frac{x}{r}\right)^2 -, \&c.\right\}$$

a series of which all the terms after the second may be neglected, by reason of their smallness.

It is easy to see, that as the base is not, correctly speaking, a straight line, but an arc of a circle, or rather ellipse, the sum of the lengths of all the rods or chains horizontally applied to it is not precisely the length of the arc, but of the circumscribing polygon. In order to determine how far this circumstance can affect the result, let us suppose the length of the measuring rod to be ten feet; when laid on the ground, exactly in the horizontal plane, it forms two tangents to the surface, of five feet each, and therefore each half length of the rod ought to be diminished by the difference between the tangent whose length is five feet, and the arc to which it belongs. Let A be the arc, then (ALGEBRA, Sect. XXV. H. 2)

$$\frac{\text{A}}{r}=\frac{\text{tan. A}}{r}-\tfrac{1}{3}\,\frac{\text{tan. A}^3}{r^3}+\&\text{c.}$$

whence $\text{tan. A}-\text{A}=\tfrac{1}{3}\,\frac{\text{tan. A}^3}{r^2}=\frac{125}{3r^2}$.

This must be multiplied by the number of times that the half rod, or five feet, is contained in the whole base. Supposing the base to be five miles, or 5280 times the length of the half rod, and the radius of the earth to be 4000 miles, or 4000 × 5280 feet, we should have tan. A — A $=\frac{125}{3\times 4000^2\times 5280}$ feet; a quantity which is altogether insensible.

We come now to the triangulation. The first thing to be done is to select proper stations for the vertices of the triangles. The selection will necessarily depend on the nature of the country through which the survey is made; but there are certain principles which ought to be observed, as nearly as the circumstances will permit. The stations should be chosen, so that each angle of the principal triangles should approach as nearly as possible to 60°, because a small error in the estimation of a very acute or obtuse angle will greatly affect the length of the opposite side computed from it. Excepting in unavoidable cases, no angle ought to be less than 30°. The sides cannot be too long, while the signal at one extremity is visible from the other. The signals may be towers, spires, or other conspicuous objects conveniently situated; but such signals can seldom be well bisected by the wire of the telescope. Flag-staffs are better when the distances are not too great. Delambre preferred signals erected on purpose. They were generally constructed of wood, and of the form of a truncated pyramid. One considerable advantage arises from the use of signals constructed in this manner, namely, that the instrument can be placed exactly at the centre of the station. Frequently Bengal lights, reverberating lamps, and white lights, are employed; but these of course can only be seen during the night. The best signal of this sort was invented by Lieutenant Drummond. It is formed by directing a stream of hydrogen gas on a small piece of ignited quicklime; an intense light is produced, which may be seen at very great distances. Care should be taken to place the signals, if they are to be observed by day, in such positions that they may be projected on the sky; if projected on forests or mountains, they will seldom be distinctly visible. Svanberg constructed his signals with openings, to permit the light of the sky to be seen through them.

The triangles being marked out, and the signals prepared, the next object is to measure the angles. When the theodolite is used for this purpose, no correction is required on account of the different altitudes of the signals, the reduction being effected by the instrument itself; but when a sextant or repeating circle is employed, the observed angles must be reduced to the plane of the horizon.

Let P, Q, and R (fig. 2), be the three stations, PQR the observed angle oblique to the horizon; produce PQ and PR till they meet Q′R′, a line parallel to the plane of the horizon; through Q′R′ let a plane be conceived to pass parallel to the horizontal plane, meeting PZ, the vertical passing through P, in P′; then Q′P′R′ is the horizontal projection of QPR, and the angles ZPQ, ZPR are the complements of the inclinations of the line PQ and PR to the horizon.

With P as a centre, and a radius = 1, let a sphere be described, intersecting PZ, PQ, and PR in the points A, B, and C respectively; the angle BAC is evidently equal to the horizontal angle Q′P′R′. Now, in the spherical triangle ABC, we have given by observation the side AB = the zenith distance of Q, AC = the zenith distance of R, and BC the oblique angle at the centre of the station, from which we are to find the angle BAC = Q′P′R′.

Let BC $=a$, AC $=b$, AB $=c$, and BAC = A. By a well-known formula of spherical trigonometry,

$$\text{cos. A}=\frac{\text{cos.}\,a-\text{cos.}\,b\,\text{cos.}\,c}{\text{sin.}\,b\ \text{sin.}\,c};\ \text{but cos. A}=1-2\ \text{sin.}^2\,\tfrac{1}{2}\,\text{A},$$

$$\text{therefore } 2\ \text{sin.}^2\,\tfrac{1}{2}\text{A}=1-\frac{\text{cos.}\,a-\text{cos.}\,b\ \text{cos.}\,c}{\text{sin.}\,b\ \text{sin.}\,c},$$

$$\text{and } 2\ \text{sin.}^2\,\tfrac{1}{2}\text{A}=\frac{\text{cos.}\,(b-c)-\text{cos.}\,a}{\text{sin.}\,b\ \text{sin.}\,c}.$$

Now, if p and q denote two arcs, we have (Algebra, XXV. D),

$$\text{cos.}\,p-\text{cos.}\,q=-2\ \text{sin.}\,\tfrac{1}{2}\,(p+q)\ \text{sin.}\,\tfrac{1}{2}\,(p-q),$$

therefore

$$\begin{aligned}\text{cos.}(b-c)-\text{cos.}\,a&=-2\ \text{sin.}\,\tfrac{1}{2}\,(a+b-c)\ \text{sin.}\,\tfrac{1}{2}(b-c-a)\\&=2\ \text{sin.}\,\tfrac{1}{2}\,(a+b-c)\ \text{sin.}\,\tfrac{1}{2}\,(a-b+c),\end{aligned}$$

and the equation becomes

$$\text{sin.}^2\,\tfrac{1}{2}\ \text{A}=\text{sin.}\ \frac{\tfrac{1}{2}(a+b-c)\ \text{sin.}\,\tfrac{1}{2}(a-b+c)}{\text{sin.}\,b\ \text{sin.}\,c}.$$

Let $\tfrac{1}{2}(a+b+c)=s$; then $\tfrac{1}{2}(a+b-c)=s-c$, and $\tfrac{1}{2}(a-b+c)=s-b$; consequently

$$\text{sin.}\,\tfrac{1}{2}\text{A}=\left(\frac{\text{sin.}\,(s-c)\ \text{sin.}\,(s-b)}{\text{sin.}\,b\ \text{sin.}\,c}\right)^{\frac{1}{2}}.$$

From this formula the value ot A is easily computed, when the inclinations of the lines PQ and PR to the horizon are not very small. In practice, however, it frequently happens that these inclinations are very small, or that the angles b and c differ very little from right angles. When this is the case, the logarithmic calculation of the formula becomes troublesome, particularly if it is required to determine A with great exactness; and it is better to adopt a different method of proceeding.

Instead of seeking to find the projected angle Q′P′R′, we may find its difference from the observed angle QPR, which difference will seldom amount to more than a few seconds. Since the arcs b and c are supposed to differ little from 90°, if we make $b=90°-\beta$, $c=90°-\gamma$, the angles β and γ will be very small. Substituting these values of b and c in the formula

$$\text{cos. A}=\frac{\text{cos.}\,a-\text{cos.}\,b\ \text{cos.}\,c}{\text{sin.}\,b\ \text{sin.}\,c}$$

it becomes

$$\text{cos. A}=\frac{\text{cos.}\,a-\text{sin.}\,\beta\ \text{sin.}\,\gamma}{\text{cos.}\,\beta\ \text{cos.}\,\gamma};$$

but

$$\text{sin.}\,\beta=\beta-\frac{\beta^3}{6}+\&\text{c., sin.}\,\gamma=\gamma-\frac{\gamma^3}{6}+,\ \&\text{c.}$$

$$\text{cos.}\,\beta=1-\frac{\beta^2}{2}+\&\text{c., cos.}\,\gamma=1-\frac{\gamma^2}{2}+,\ \&\text{c.};$$

therefore, on substituting, and rejecting all terms above those of the second order, we have

$$\text{cos. A}=\frac{\text{cos.}\,a-\beta\gamma}{1-\tfrac{1}{2}(\beta^2+\gamma^2)}=\text{cos.}\,a-\beta\gamma+\tfrac{1}{2}(\beta^2+\gamma^2)\ \text{cos.}\,a.$$

Let $\text{A}=a+x$. It is evident that when β and γ both vanish, x also vanishes, and we get $\text{A}=a$. Hence if β and γ be both very small, x is also very small, and consequently we may suppose its cosine $=1$, and its sine $=x$. In this case $\text{cos. A}\left\{=\text{cos.}\,(a+x)\right\}=\text{cos.}\,a\ \text{cos.}\,x-\text{sin.}\,a\ \text{sin.}\,x$ becomes

$$\text{cos. A}=\text{cos.}\,a-x\ \text{sin.}\,a.$$

Equating this with the former value of cos. A, we get

$$x\ \text{sin.}\,a=\beta\gamma-\tfrac{1}{2}(\beta^2+\gamma^2)\ \text{cos.}\,a,$$

whence

$$x=\frac{\beta\gamma-\frac{1}{2}(\beta^2+\gamma^2)\cos. a}{\sin. a}.$$

In order to adapt this fraction to logarithmic computation, let both its numerator and denominator be multiplied by 2; then, because $\cos. a=\cos.^2\frac{1}{2}a-\sin.^2\frac{1}{2}a$, and $2\beta\gamma=2\beta\gamma\cos.^2\frac{1}{2}a+2\beta\gamma\sin.^2\frac{1}{2}a$, we find, on multiplying and reducing,

$$2\beta\gamma-(\beta^2+\gamma^2)\cos. a=(\beta+\gamma)^2\sin.^2\tfrac{1}{2}a-(\beta-\gamma)^2\cos.^2\tfrac{1}{2}a;$$

but $\sin. a=2\sin.\frac{1}{2}a\cos.\frac{1}{2}a$; therefore, by substitution,

$$x=\left(\frac{\beta+\gamma}{2}\right)^2\tan.\tfrac{1}{2}a-\left(\frac{\beta-\gamma}{2}\right)^2\cot.\tfrac{1}{2}a.$$

Here the arcs x, β, γ are expressed in parts of the radius; but they are given by observation in minutes and seconds. Now an arc of 1″ may be considered as equal to its sine: hence the arc in seconds is to the arc in parts of the radius as 1″ to sin. 1″; consequently the arc in feet is equal to the arc in seconds × sin. 1″. Multiplying, therefore, by sin. 1″, we get

$$x=\left\{\left(\frac{\beta+\gamma}{2}\right)^2\tan.\tfrac{1}{2}a-\left(\frac{\beta-\gamma}{2}\right)^2\cot.\tfrac{1}{2}a\right\}\sin. 1''.$$

Another reduction is necessary. Unless the signals are constructed on purpose, it will rarely happen that the instrument can be placed exactly in the centre of the station. In this case it must be placed at some other point near the centre of the station, and the observed angle reduced to the centre by calculation. Suppose, for example, it were required to determine the angle ACB (fig. 3), which the objects A and B subtend at C, and that the instrument cannot be placed exactly at C. Let P be the point, at a short distance from C, where the instrument is actually placed, and APB be the observed angle; then, since CP can be measured, and CA, CB are supposed to be known, approximately at least, the problem is, having given the angle APB, and the distances CA, CB, and CP, it is required to determine the angle ACB.

Let AC and BP intersect in E. Then, since AEB= ACB+CBP=APB+CAP, we have

$$\text{ACB}-\text{APB}=\text{CAP}-\text{CBP}.$$

But $\sin.\text{CAP}=\frac{\text{CP}}{\text{CA}}\sin.\text{CPA}$, and likewise $\sin.\text{CBP}=\frac{\text{CP}}{\text{CB}}\sin.\text{CPB}$; therefore, making AC=$m$, BC=$n$, CP=$d$, ACB=C, APB=P, CPB=$p$, then CPA=P+$p$, and by substitution,

$$\sin.\text{CAP}=\frac{d}{m}\sin.(\text{P}+p),\text{ and }\sin.\text{CBP}=\frac{d}{n}\sin. p,\text{ whence,}$$

dividing by sin. 1″ to reduce the expression to seconds,

$$\text{CAP}=\frac{d}{m}\,\frac{\sin.(\text{P}+p)}{\sin. 1''},\text{ and CBP}=\frac{d}{n}\,\frac{\sin. p}{\sin. 1''};$$

therefore (since CAP − CBP = ACB − APB = C − P),

$$\text{C}-\text{P}=\frac{d\sin.(\text{P}+p)}{m\sin. 1''}-\frac{d\sin. p}{n\sin. 1''},$$

which gives C, or the angle ACB, expressed in seconds of a degree.

This expression is exact; but an approximation more convenient for calculation, and sufficient in almost every case that can occur in practice, was generally followed by Delambre. Let a circle be described about the triangle ABC, intersecting BP in D, and let CD, DA, and AB be joined. We have then ACB − APB=ADB − APB=DAP. Let the angle CDB (=CAB, which is known by observation) be denoted by A. In the triangle DPA,

$$\sin.\text{DAP}=\frac{\text{DP}}{\text{AD}}\sin.\text{APB}=\frac{\text{DP}}{\text{AD}}\sin.\text{P},$$

and in the triangle DPC,

$$\text{DP}=\text{PC}\frac{\sin.\text{PCD}}{\sin.\text{CDB}}=\text{PC}\frac{\sin.(\text{CDB}-\text{CPB})}{\sin.\text{CDB}},$$

$$\text{or DP}=d\,\frac{\sin.(\text{A}-p)}{\sin.\text{A}};\text{ therefore}$$

$$\sin.\text{DAP}=\frac{d}{\text{AD}}\,\frac{\sin.(\text{A}-p)}{\sin.\text{A}}\sin.\text{P}.$$

But AD may be considered as equal to AC=m; whence $\sin.\text{DAP}=\frac{d\sin.(\text{A}-p)\sin.\text{P}}{m\sin.\text{A}}$, and consequently, when expressed in seconds,

$$\text{DAP}=\text{C}-\text{P}=\frac{d\sin.(\text{A}-p)\sin.\text{P}}{m\sin.\text{A}\sin. 1''}.$$

This expression vanishes when A − p=0, or when the points P and D coincide, that is, when the instrument is placed on the circumference of the circle, circumscribing the triangle ACB. And it may be so placed, unless obstacles intervene, by moving it along the line PB, till the angle CDB is observed to be equal to BAC.

When the three observed angles of each triangle have been reduced to the horizon, they represent the angles of a spherical triangle, the sides of which are intercepted by the verticals of the three stations, and the sum of the three angles of each triangle exceeds 180° by a quantity which is called the *spherical excess*. The sides ought therefore to be calculated by the rules of spherical trigonometry; but as the sides of the triangles are in all cases very small in comparison of the radius of the earth, the calculation made in this way (for which indeed the existing tables are not well adapted) becomes exceedingly tedious. Instead, therefore, of calculating directly the spherical triangle, it is more convenient to compute its deviation, which is always very small, from a plane triangle. The method employed by Delambre was the following.

In the first place, the spherical angle, or that which is formed by tangents at the surface, must be reduced to the corresponding plane angle formed by the chords. This is easily accomplished by the help of the theorem above given for reducing the observed angles to the horizon; for the angle formed by the chord and the tangent of an arc is equal to the angle at the centre subtended by half the arc; consequently when the lengths of the two sides of a spherical angle are known nearly, the angle of *depression* of the chords is also known; and therefore the preceding theorem for reducing angles to the horizon can be immediately applied. For example, suppose the sides of a spherical angle to be respectively p and q miles, and the circumference of the earth to be 25,000 miles, then

$$25{,}000 : p :: 360^\circ : \frac{360^\circ\,p}{25{,}000},\text{ or }\frac{21{,}600''p}{25{,}000}=\frac{108\,p}{125}\text{ seconds}$$

of a degree, which is the angle subtended at the centre by the whole arc; and consequently one half of it, or $\frac{54''p}{125}$, is the depression of the chord. In the same manner, $\frac{54''q}{125}$ is the depression of the chord of q; and by substituting these in the formula

$$x=\left\{\left(\frac{\beta+\gamma}{2}\right)^2\tan.\tfrac{1}{2}a-\left(\frac{\beta-\gamma}{2}\right)^2\cot.\tfrac{1}{2}a\right\}\sin. 1'',$$

we obtain the angles made by the chords, by means of which the triangle may be computed in the same manner as if it were a plane triangle.

To make this reduction, it is necessary to know, approximately at least, the diameter of the earth as well as the distances of the stations; but the result will be little affected by a moderate error in either of these data. In fact, it is only when the sides of the triangles are very large that the effects of the earth's curvature become at all sensible.

But a more elegant manner of estimating the effects of the earth's curvature, though not always of so easy application, was proposed by Legendre. This illustrious geometer discovered the following very remarkable property of spherical triangles; namely, that when the sides are very small in comparison of the radius of the sphere, if from each of the angles there be subtracted one third part of the quantity by which the sum of the three angles exceeds two right angles, or 180°, the angles thus diminished may be regarded as the angles of a plane triangle, the sides of which are equal in length to those of the proposed spherical triangle. The excess of the sum of the three angles above two right angles is proved by trigonometry to be equal to $\frac{a}{r^2}$, a being the area of the triangle, and r the radius of the sphere; so that the theorem of Legendre may be enumerated as follows:

"If the angles of a spherical triangle whose surface is small in comparison of the surface of the whole sphere, be denoted by A, B, and C, and the opposites by a, b, and c, the triangle may be calculated as a plane triangle, the sides of which are a, b, and c, and the opposite angles $A - \frac{1}{3}\varepsilon$, $B - \frac{1}{2}\varepsilon$, $C - \frac{1}{3}\varepsilon$, ε being the excess of the sum of the three angles of the proposed spherical triangle above two right angles."

In applying the above theorem, it is necessary first to calculate ε or $\frac{a}{r^2}$, which can always be done *a priori* from the known parts of the spherical triangle considered as rectilinear. This being done, we have only to deduct $\frac{1}{3}\varepsilon$ from each of the observed angles, and then compute the remaining parts, as in the case of a plane triangle.

By this method, the distances between the several signals may be computed; and as the angles at all the stations are given by observation, the inclinations of all the sides of the triangles to any one of them are also known, so that it is only necessary to determine very accurately the inclination of one side of a triangle to the meridian, in order to ascertain the inclinations of all the other sides, and thence to compute the meridian itself.

The determination of the azimuth of a signal is accomplished by means of astronomical observation, and may be performed in various ways, but all depending on the same principle. It is necessary, however, in any case to be provided with the means of determining the time with very great precision. The azimuth of the sun, or a star, at any given instant, can be determined with sufficient accuracy. Let the observer, therefore, take his station at one of the signals, and observe the angle formed between the other signal and the sun, or a star, when nearly in the horizon, and let him note the instant of time at which the observation was made. Knowing the error of his clock or chronometer, he knows also the true time, and can consequently calculate the azimuth of the observed celestial body. Taking the sum or difference, as the case may be, of this and the observed angle, he obtains the azimuth of the distant signal, or the angle which the straight line joining the two signals makes with the meridian. The refraction will scarcely effect the result; but a small error with respect to the time would lead to considerable errors. If the sun is observed, the error of the clock must be determined by observations of his meridional transits; but most frequently a circumpolar star, as Capella, is preferred. Sometimes the observation is made on the pole star itself; but in this case it is necessary to know the latitude of the station very accurately. Another method is frequently resorted to. Having set up a mark very nearly in the meridian, adjust a transit instrument upon it, and then, by means of the transits of stars at different polar distances, or other means known in practical astronomy, determine the deviation of the instrument from the meridian. This gives the direction of the mark with respect to the meridian, and consequently the angle to be added to or subtracted from the angle between the mark and the signal. For greater security, the azimuths may be observed at several signals. They ought at least to be observed at each extremity of the chain of triangles.

The triangles being calculated and reduced to the horizon, we are now in a condition to compute the length of the arc between the parallels of the extreme stations. Let ABCDEFG, &c. (fig. 4), be a chain of triangles lying nearly in the direction of the meridian AZ, and traced on a spheroidal surface, supposed to be formed by the continuation of the ocean. Let L be the last station, and LX the perpendicular passing through L and meeting AZ in the point X; it is required to determine AX.

By means of the previous calculations, all the sides of the triangles are supposed to have been computed, as well as the azimuth of C, or the inclination of AC to the meridian. Let CD be produced to M. In the triangle ACM there are given the side AC, and the two angles CAM, ACM. To find the third angle AMC, first compute the spherical excess ε; from each of the angles CAM, ACM, subtract $\frac{1}{3}\varepsilon$; take the sum of the two remainders from 180°, and there will be left the value of AMC. The angles being thus given, and also the side AC, the other two sides AM and CM are computed in the same manner as if the triangle were rectilinear.

In the quadrilateral MDFN there are given the two opposite angles at M and F (the first from the previous calculation, and the second by observation), together with the two sides MD and DF. Draw the diagonal MF; then in the triangle DMF there are given the two sides DM, DF, and the included angle D. From D deduct $\frac{1}{3}\varepsilon$, the excess ε being computed by an approximate value of the area of the triangle, and compute, as in a plane triangle, the side MF and the two angles DMF, DFM. To each of these add $\frac{1}{3}\varepsilon$, and the two sums being deducted from the angles DMN and DFN, there will remain the two angles FMN and MFN. Hence, since MF has been already computed, we can find MN, FN, and the angle MNF, in the usual manner.

Now, in the triangle NPH, NH is known (for FH and FN have been calculated), and the adjacent angles PNH, NHP are given by observation; therefore we can compute NP, PH, and the remaining angle NPH.

To find PX we may produce IL to Z, and resolve the two triangles PIZ and ZLX. In the first of these, the side PI, and the two adjacent angles PIZ, IPZ, are already known; whence we find IZ, PZ, and the angle IZP. We have then in the right-angled triangle LXZ, the side LZ, and the angle LZX to find ZX. From PZ subtract ZX, and there remains PX, the quantity sought.

In proceeding by the method now indicated, the spherical excess ε must be first computed for each of the triangles to be resolved; then each observed spherical angle must be diminished by $\frac{1}{3}\varepsilon$, in order to allow the calculations to be made by the rules of plane trigonometry; and when the result has been found, we must again add to each angle the small quantity $\frac{1}{3}\varepsilon$, in order to have the true spherical angle. (See Delambre, *Methodes Analytiques pour la Determination d'un Arc du Meridien.*)

It is necessary to remark, that the point X, determined by drawing a perpendicular from the last station to the meridian, is not situated exactly on the same parallel of latitude with L. Its latitude is a little greater than that of L; and unless the distance of the station from the meridian is very small, the difference will be sensible, and requires to be calculated. Conceive another point, L′ (fig. 5), on the same parallel of latitude with L, and at the same distance from the meridian on the opposite side. The point X is on the circumference of a great circle, perpendicular to the meridian PE, and passing through L and L′; but the small circle, or parallel of latitude of L and L′, intersects the meridian in a different point *l*. Now let PE (fig. 6) be the meridian, XC the intersection of its plane with that of the great circle passing through the points LL′, and *ln* the intersection of the plane of the meridian and the plane of the small circle or parallel of latitude passing through the same points LL′, so that E*l* is the latitude of L, EX that of the point X, and *l*X the distance between the perpendicular and the small circle passing through L. Let *ln* and XC intersect in *m*, then *l*X being a small arc, may be regarded as a straight line; consequently X*l* = *m*X tan. X*ml*. But X*ml* = XCE = latitude of L very nearly, consequently, taking λ to denote the latitude of L, we have X*l* = *m*X tan. λ. Now *m*X is the versed sine of the arc whose chord is LX; therefore, making $d =$ earth's diameter, $mX = \frac{LX^2}{d}$, and consequently $Xl = \frac{LX^2}{d} \tan.\ \lambda$, which is the quantity to be subtracted from the calculated meridional arc.

Delambre employed a different method of computing the distance between the parallels of the terminal points of the measured arc. It requires, however, the dimensions of the earth to be previously known with tolerable accuracy. Let AB (fig. 7) be the arc measured on the surface of the spheroid PAB; then, having observed the latitude of the station A, and the azimuth of AB, that is the angle BAP, we have sufficient data, supposing the dimensions of the earth to be nearly known, to find not only the distance between the parallels of A and B, but also the latitude and longitude of B, and the azimuth of BA, as observed from B. Through A and B draw the normals AM and BN, meeting the axis in M and N; join BM, AN; and about M as a centre, with an arbitrary radius, describe the circular arcs *bp*, *pa*, *ab*, forming the spherical triangle *pab*. Now, if we compare the triangle PAB on the spheroid with *pab* on the sphere, we find *pa* = PA in degrees, each being the colatitude of A; *pb* = PB, each being the colatitude of B; the angle *apb* = APB being the difference of longitude of A and B, and also the angle *pab* = PAB, each measuring the inclination of the planes PMA, AMB. But the angle *pba* is in general not equal to PBA; for as the normals do not meet the axis in the same point, the planes AMB and ANB do not coincide; and *pba* is the measure of the inclination of PMB and AMB, whereas PBA is the measure of the inclination of PMB and ANB. Now, in the triangle *pba* there are given the angles at *p* and *a*, so that if the side *ab* can be determined in terms of AB, the other parts of the triangle may be computed, and thence the difference between *pb* and *pa*, or the distance between the parallels, which being found in terms of BA, will be expressed in feet.

We have therefore to find an expression for *ab*, or the angle AMB. Now, in the triangle ABM there are given AB (the measured arc), and AM the normal at A (the dimensions of the earth being nearly known). But $BM = BN \frac{\sin.\ MNB}{\sin.\ NMB}$; and if we make $l =$ PNB the colatitude of B, and $x =$ NBM, we shall have $NMB = PNB - x = 90° - l - x$; therefore $\sin.\ NMB = \cos.\ (l + x)$; we have also $\sin.\ MNB = \sin.\ (90° - l) = \cos.\ l$; wherefore

$$BM = BN \frac{\cos.\ l}{\cos.\ (l + x)} =$$

$$BN \frac{\cos.\ l}{\cos.\ l \cos.\ x - \sin.\ l \sin.\ x} = BN \frac{1}{\cos.\ x - \tan.\ l \sin.\ x}$$

$$= BN\ (1 + \tan.\ l \sin.\ x + 2 \sin.^2 \frac{x}{2} +, \&c.$$

Now *x* is a very small angle; its sine is in fact expressed in terms of the square of the eccentricity, so that terms multiplied by it may be neglected without any sensible error. We may therefore assume BM = BN. In the triangle ABM we have then given the three sides, whence the angles may be computed, and consequently *ab* = AMB becomes known.

Having found *ab*, we have given in the triangle *abp* the two sides *pa*, *ab*, and the observed angle *pab*, from which to compute the remaining parts of the triangle, viz. *pb* the latitude of B, *apb* its longitude, and *pba* the azimuth of A, as seen from B. Make *pa′* = *pa*, and P*b′* to PB, then *ba′* = *pb* — *pa* is the distance between the parallels, the radius being unit; therefore, since 1 : MA : : *a′b* : A*b′*, we have A*b′* = AM × *a′b*, that is, the distance between the parallels of the extreme stations on the spheroid.

When the distance between the parallels of the extreme points of the arc has been ascertained, it only remains to determine the difference of their latitudes, or the length of the corresponding celestial arc. This is the most difficult part of the whole operation. The error of a single second in the difference of the latitudes corresponds to about a hundred feet on the terrestrial meridian; and when it is considered that the latitudes of the best determined spots on the earth, even of the Observatories of Greenwich and Paris, are still uncertain to the amount of at least half a second, it will be easily apprehended that the errors of the latitudes are more to be feared than any which can affect the measurement of the base, or the angles, or the direction of the meridian. In the British survey, that of India, and some on the Continent, the latitudes were observed with the zenith sector, an instrument peculiarly adapted to this purpose. Ramsden's zenith sector, made expressly for the determination of the arc of meridian between Dunnose and Clifton, carried a telescope of eight feet in length. With this superb instrument, for a description of which we must refer to the second volume of the *Trigonometrical Survey*, the zenith distances of several of the northern stars were observed at both extremities of the arc; and the difference of two zenith distances of the same star is evidently the same as the difference of the latitudes of the two stations. It may be remarked, that the result of this observation is independent of the declination of the star; and if the observation is made at the second station within a short time after it was made at the first, the result is also nearly independent of the nutation.

For the determination of the French arc of meridian, the latitudes were observed with the repeating circle. This instrument, on account of its portability, is of the greatest use in geodetic operations; but it may be questioned whether it can be safely relied on for the determination of so very important an element as the latitude. Besides the want of power in the telescope, it is found to be affected in some unaccountable way by a constant error, which, however carefully its amount may have been determined, leaves a degree of uncertainty with regard to the results. Mechain mistook the latitude of Barcelona by about 3″. It is to be regretted that the latitudes of Dunkirk and Formentera, the extremities of the French arc, have not been determined with the zenith sector. All the other operations connected with the measurement of that extensive arc have been executed in a style of such decided superiority, that a more satisfactory, if not more accurate, determination of the latitudes is alone wanting to render it the most valuable application of science that has ever been made with a view to ascertain the magnitude and exact figure of our globe.

The measurement of an arc of parallel usually forms part of the operations connected with the survey of a large extent of country. It will frequently happen that the sides of some of the great triangles lie in a direction nearly perpendicular to the meridian, in which case the arc of the terrestrial parallel may be easily computed from an approximate knowledge of the earth's dimensions; and if the difference of longitude of the two stations, or the angle which their respective meridians make with each other, has been accurately determined, the comparison of the corresponding celestial and terrestrial arcs will give the length of the degree on the parallel. By comparing this result with the length of a degree measured on a different parallel, or on the meridian, we can easily deduce the ellipticity.

Perhaps the simplest way of conveying an accurate idea of the nature of the operations necessary to be undertaken in the measurement of an arc of parallel, will be to describe the method that was actually followed in the British trigonometrical survey, in determining the length of an arc of parallel from the measured distance between Beachy Head and Dunnose.

Let BW (fig. 8) be an arc of the great circle perpendicular to the meridian of Beachy Head at B, meeting that of Dunnose in W; and let DR be an arc of the great circle perpendicular to the meridian of Dunnose at D, meeting that of Beachy Head in R; and let BL and DE be the parallels of latitude passing through B and D. It is supposed that the latitudes of the two places have been determined, together with the angles PBD and PDB, which they reciprocally make with each other and the pole; and also that the distance between them on the arc of the great circle has been measured: the question is then to find the difference of their longitudes, or the angle BPD, and the distance in feet between the meridians on the arcs of the small circles BL and DE passing through the places.

In the small spheroidal triangle WBD there were given by observation the two angles WBD and WDB, which being reduced to the angles made by the chords, gave the two angles of the corresponding plane triangle. The side BD was found by triangulation = 339,397·6 feet; whence the chord of the perpendicular arc BW was found = 336,115·6 feet. In like manner the chord of DR was found = 336,980 feet.

The terrestrial distances being thus found, it was next necessary to find the difference of longitude, or the angle P, and the lengths of the arcs of parallel BL and DE in degrees. For this purpose there are given PB the colatitude of B, PD the colatitude of D, the angle PBD, which is the azimuth of D as seen from B, and PDB the azimuth of B as seen from D.

The rigorous solution of this problem on the spheroid is attended with considerable difficulty. An approximation is however easily obtained from a property of spheroidal triangles (for the demonstration of which we must refer to the *Phil. Trans.* vol. lxxx.), namely, that the sum of the horizontal angles on a spheroid (or indeed on any surface differing little from that of a sphere) is *nearly* the same as the sum of those which would be observed on a sphere, the latitudes and difference of longitudes being the same on both figures. Assuming therefore the sum of the two angles PDB and PBD to be the same as the sum of two spherical angles, we have, from Napier's analogies (see TRIGONOMETRY),

$$\cos.\tfrac{1}{2}(\mathrm{PD}+\mathrm{PB}) : \cos.\tfrac{1}{2}(\mathrm{PD}-\mathrm{PB})$$
$$= \cot.\tfrac{1}{2}\,\mathrm{P} : \tan.\tfrac{1}{2}(\mathrm{PDB}+\mathrm{PBD}),$$

whence

$$\tan.\tfrac{1}{2}\,\mathrm{P} = \frac{\cos.\frac{1}{2}(\mathrm{PD}-\mathrm{PB})}{\cos.\frac{1}{2}(\mathrm{PD}+\mathrm{PB})} \times \cot.\tfrac{1}{2}(\mathrm{PDB}+\mathrm{PBD});$$

that is to say, the tangent of half the difference of longitudes is equal to the cotangent of half the sum of the azimuthal angles multiplied into the ratio of the cosine of half the difference of the colatitudes to the cosine of half their sum. In the case under consideration the angle P was found = 1° 26′ 47″·93.

We have now given, in the right-angled triangle PBW, which may be considered as spherical, the side PB and the angle P, whence BW was found = 54′ 56″·21. And from the triangle PDR, in which the side PD and the angle P are given, DR was found = 55′ 4″·74.

The chords of the two perpendicular arcs BW and DR, whose radius is the radius of the earth, are found, from an approximate knowledge of the earth's diameter, to be three feet and a half shorter than the arcs themselves, whence the arc BW = 336,119·1 feet, and DR = 336,983·5 feet. Hence the length of the degree of the great circle perpendicular to the meridian, at the middle point between W and B, is found by proportion = 367,096·8 feet, and in the middle point between R and D = 367,090·8 feet. Therefore the mean, or 367,093·8, is the length of a degree of the great circle perpendicular to the meridian in latitude 50° 41′, which is nearly that of the middle point between Beachy Head and Dunnose.

Now, by reason of the short distance between the two stations, and their small difference in latitude, the two radii of curvature at B and D may be regarded as intersecting each other on the axis at M (fig. 9). Therefore DM is the radius of the great circle perpendicular to the meridian, and DE is the radius of the parallel at D. Therefore 1° of the great circle : 1° of the parallel as DM : DE; and DM : DE = 1 : cos. latitude of D; whence 1 : cos. 50° 44′ 24″ = 367,094 : 232,314 feet for the degree of parallel at Beachy Head, and 1 : cos. 50° 37′ 7″ = 367,094 : 232,914 feet for the degree of parallel at Dunnose. (*Trig. Survey*, vol. i. p. 113.)

The length of the degree of the great circle perpendicular to the meridian, deduced in the manner now explained, is about 1250 feet greater than on the spheroid which corresponds with the measurements of the meridional arcs. This discrepancy gave rise to a suspicion of errors in the observation of the azimuthal angles; and, in fact, the difference of longitude, in order to agree with other determinations, ought to be about 18″ greater than that which was determined in the survey. With this correction the length of the degree of the perpendicular circle is found = 365,838 feet. Assuming the dimensions of the earth deduced from the survey, the length of the degree perpendicular to the meridian at the mean latitude is 365,844 feet. Hence 1° parallel = 231,801 feet.

In the *Philosophical Transactions* for 1824 an account is given of some experiments performed by Dr Tiarks for determining the difference of longitude of Dover and Falmouth. Twenty-four chronometers were transported by sea, three several times, from the one place to the other, by which means the difference of the apparent times was determined. The difference of longitude was thus found to be 6° 22′ 6″; and the length of the parallel, as found from the survey, being 1,474,672 feet, we have the length of a degree of parallel at latitude 50° 44′ 24″ = 231,563 feet.

The most extensive arc of parallel which has yet been measured is that between Marennes (near Bordeaux) and Padua. The details of the operations, which were performed in 1822 and 1823, are given in the *Connaissance de Tems* for 1829. The terrestrial arc was determined by triangulation in the usual manner, and the astronomical amplitude by fire signals observed from station to station at five intermediate stations. There are consequently six independent arcs; and the final result is affected with the accumulated errors at all the stations. The terrestrial distance was found to be 1,010,996 mètres, or 3,316,976 English feet; and the difference of time determined by chronometers 51 min. 56·24 sec., corresponding to 12° 59′ 3″·75 of longitude. The mean length of the degree, found from the partial arc between Marennes and Geneva, is 255,546 feet, and from the whole arc between Marennes and Padua 255,470 feet, both of which results are greater than the degree on the regular spheroid, which is found to represent most nearly the meridional arcs under the same parallel of latitude, namely, 45° 43′ 12″. No great reliance, however, can be placed on this determination, on account of the uncertainty that exists respecting some of the longitudes, the determination of which was found to be attended with great difficulty. If the difference of longitude of Marennes and Padua were found by good astronomical observations, the discrepancies would probably be diminished.

SECTION III.

DETERMINATION OF THE FIGURE OF THE EARTH FROM GEODETIC MEASURES.

Assuming the figure of the earth to be that of an elliptic spheroid of revolution, the magnitude and ratio of its equatorial and polar diameters may be determined from the comparison of the lengths of lines measured between determined points on its surface, with the corresponding arcs of the celestial sphere, by means of theorems which we shall now proceed to demonstrate.

1. *To express the radius of curvature of a meridian in terms of the latitude.*

Let PDQ (fig. 10) be the meridian, CP half the polar axis, CQ the radius of the equator, DM a perpendicular to the tangent at D, meeting CP in M, and CQ in N; and let

a = CP half the polar axis,
b = CQ the radius of the equator,
n = DN the normal at D,
r = radius of curvature at D.

Join CD; let CD′ be the diameter conjugate to CD, meeting DM in G; and through D draw DE and DF respectively perpendicular to CP and CQ. It is demonstrated in the article Conic Sections (Part IV. Sec. 2, Prop. V. Cor. I.), that $r \times$ DG = CD′^{2}; and (Prop. XVII. Part II.) CD′ × DG = CP × CQ = ab; whence CD′^{2} = $a^2 b^2 \div$ DG^2; and consequently $r \times$ DG$^3 = a^2 b^2$. But (Prop. XXI. Part II.) DN × DG = CP^2; that is, $n \times$ DG $= a^2$; whence $n^3 \times$ DG$^3 = a^6$, and therefore DG$^3 = a^6 \div n^3$, consequently

$$r=\frac{b^2 n^3}{a^4}\text{.....................................(1.)}$$

Again (Prop. XXI. Part II.) DN : DM = $a^2 : b^2$; and the triangles NCM, NFD being similar, DN : DM = NF : CF, whence CF = $\frac{b^2}{a^2}$ NF. Now let the angle DNF or the latitude of D = l; then DF = n sin. l, NF = n cos. l, and CF = $\frac{b^2}{a^2} n$ cos. l. But DF = CE = x and CF = y; substituting therefore n sin. l for x, and $\frac{b^2}{a^2} n$ cos. l for y in the equation of the ellipse, namely,

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1,$$

we find

$$\frac{n^2\sin.^2 l}{a^2}+\frac{b^2 n^2\cos.^2 l}{a^4}=1,$$

whence

$$n^2=\frac{a^4}{a^2\sin.^2 l+b^2\cos.^2 l}.$$

Let $b = a\,(1 + e)$ (e denoting the ellipticity or the ratio of the difference of the semiaxes to the polar semiaxis, that is, $e=\frac{b-a}{a}$; by substituting, we get

$$n^2=\frac{a^2}{\sin.^2 l+(1+e)^2\cos.^2 l};$$

but since the ellipticity e is very small, all terms multiplied by the square or higher powers of e may be rejected without sensible error. Hence $(1 + e)^2 = 1 + 2\,e$, and therefore $n^2=\frac{a^2}{1+2e\cos.^2 l}$, or $n=a(1+2e\cos.^2 l)^{-\frac{1}{2}}$; whence, on developing and rejecting terms containing e^2,

$$n = a\,(1 - e\cos.^2 l)\text{.........................(2.)}$$

Now, from equation (1), $r=\frac{b^2}{a^4}n^3=\frac{1+2e}{a^2}n^3$; and from equation (2), $n^3 = a^3\,(1 - 3\,e\cos.^2 l)$; therefore $r=a\,(1+2e)\,(1-3e\cos.^2 l)=a\,(1+2e-3e\cos.^2 l)$; or, finally,

$$r = a\,(1 - e + 3\,e\sin.^2 l)\text{.................(3.)}$$

2. *To express the radius of a circle parallel to the equator in terms of the latitude.*

Suppose the parallel to pass through D, then DE = y is the radius required. But it was shown in the last Prop. that CF (= DE) = $\frac{b^2}{a^2} n$ cos. l; therefore, substituting $a^2\,(1 + 2\,e)$ for b^2, we have $y = n$ cos. $l\,(1 + 2\,e)$. Substituting in this the value of n given by equation (2), we have $y = a$ cos. $l\,(1 + 2\,e)\,(1 - e\cos.^2 l)$; whence $y = a$ cos. $l\,(1 + 2\,e - e\cos.^2 l)$, or

$$y = a\cos. l\,(1 + e + e\sin.^2 l)\text{................(4.)}$$

3. *To find an expression for the length of an arc of the meridian, in terms of the latitudes of its extreme points.*

If the arc is small, it may be regarded as coinciding with the osculating circle at its middle point. Let z = the arc, and r = the radius of curvature at its middle point; then (z being supposed small) we have $z = r$ sin. z. But z : sin. z = 1″ : sin. 1″; therefore sin. $z = z$ sin. 1″, and the length of the arc in feet = $r\,z$ sin. 1″. Now let l and l' be the latitudes at the extremities of the arc, then $\frac{1}{2}\,(l + l')$ is the latitude of its middle point; and on substituting for r its value found in equation (3), the expression for the length of a meridional arc, in terms of its extreme latitudes l' and l, is

$$z = a\left\{1-e+3e\sin.^2\tfrac{1}{2}(l+l')\right\}(l'-l)\sin. 1''\text{...(5.)}$$

But if the arc is of considerable extent, this expression will not be sufficiently exact, and it becomes necessary to find by integration the lengths of the arcs from the equator to each extremity of the given arc: the difference of these two will give z itself. At the latitude l, $dz = rdl$; therefore, from equation (3),

$$dz = a\,(1 - e)\,dl + 3\,ae\sin.^2 l\,dl,$$

and integrating,

$$z = al - ael + 3\,ae\int \sin.^2 l\,dl.$$

But $\int \sin.^2 l\,dl = \frac{1}{2}l - \frac{1}{4}\sin.\,2\,l$; therefore

$$z = a\left\{(1+\tfrac{1}{2}e)\,l - \tfrac{3}{4}e\sin.\,2\,l\right\}\ldots\ldots\ldots\ldots\ldots(6.)$$

No constant is necessary, because at the equator z and l vanish together.

Let z' be another arc reckoned from the equator to the point whose latitude is l'; then, similarly,

$$z' = a\left\{(1+\tfrac{1}{2}e)\,l' - \tfrac{3}{4}e\sin.\,2\,l'\right\};$$

and consequently

$$z' - z = a\left\{(1+\tfrac{1}{2}e)(l'-l) - \tfrac{3}{4}e(\sin.\,2\,l' - \sin.\,2\,l)\right\};$$

but $\sin.\,2\,l' - \sin.\,2\,l = 2\cos.\,(l'+l)\sin.\,(l'-l)$; therefore

$$z' - z = a\left\{(1+\tfrac{1}{2}e)(l'-l) - \tfrac{3}{2}e\cos.\,(l'+l)\sin.\,(l'-l)\right\},$$

or, as $l'-l$ is expressed in seconds, $z'-z$

$$= a\left\{(1+\tfrac{1}{2}e)(l'-l)\sin.\,1'' - \tfrac{3}{2}e\cos.(l'+l)\sin.(l'-l)\right\}(7.)$$

4. *To express the length of an arc of parallel in terms of the radius.*

Let $y =$ the radius, D $=$ the amplitude of the arc in seconds, and V $=$ its length in feet. Then, by what is shown above, the length of the arc in feet is $y\mathrm{D}\sin.\,1''$. Hence, from the value of y given in equation (4), the length of the arc of parallel at latitude l is

$$\mathrm{V} = a\cos.\,l\,(1+e+e\sin.^2 l)\,\mathrm{D}\sin.\,1''\ldots\ldots\ldots\ldots(8.)$$

5. *From the measured length of two degrees of meridian at different latitudes, to determine the axis and ellipticity of the spheroid.*

Let Z and Z′ be the measured lengths of two degrees, and the latitudes of their middle points be respectively L and L′; then (since in this case $l'-l = 1° = 3600''$) we have, by equation (5),

$$\mathrm{Z} = a\,(1 - e + 3\,e\sin.^2\mathrm{L})\,3600\sin.\,1'',$$
$$\mathrm{Z}' = a\,(1 - e + 3\,e\sin.^2\mathrm{L}')\,3600\sin.\,1'',$$

therefore

$$\frac{\mathrm{Z}'}{\mathrm{Z}} = \frac{1 - e + 3\,e\sin.^2\mathrm{L}'}{1 - e + 3\,e\sin.^2\mathrm{L}};$$

whence, performing the division, and neglecting terms multiplied by e^2,

$$\frac{\mathrm{Z}'}{\mathrm{Z}} = 1 + 3\,e\,(\sin.^2\mathrm{L}' - \sin.^2\mathrm{L}),$$

from which we find the ellipticity

$$e = \frac{\mathrm{Z}' - \mathrm{Z}}{3\,\mathrm{Z}\,(\sin.^2\mathrm{L}' - \sin.^2\mathrm{L})}\ldots\ldots\ldots\ldots\ldots\ldots(9.)$$

The accuracy of this expression will depend on the magnitude of the denominator, or the difference between L′ and L. If L is nearly equal to L′, the denominator becomes very small, and the value of e in consequence uncertain. The most favourable determination, therefore, that can be obtained is, when one of the degrees, Z′, for example, is measured near the pole, and Z at the equator, where L is zero. As an example of this method, we may deduce the value of e from a comparison of the lengths of a degree at the equator and in England. Bouguer found the length of the degree at the equator to be 362,932 English feet; and from the British arc, between Dunnose and Clifton, the length of the degree is 364,970 feet, at the latitude of 52° 35′ 45″. We have therefore Z $=$ 362,932, Z′ $=$ 364,970, L $=$ 0, L′ $=$ 52° 35′ 45″, by substituting which in equation (9), there results

$$e = \frac{2038}{3 \times 362932 \times \sin.^2(52°\,35'\,45'')},$$

whence $e = \frac{1}{346}$.

Having found the value of e, that of the polar semi-diameter, or a, is obtained as follows. At the equator, where L vanishes, we have $\mathrm{Z} = a\,(1-e)\,3600\sin.''$, whence

$$a = \frac{\mathrm{Z}}{(1-e)\,3600\sin.\,1''} = \frac{\mathrm{Z}\times 346}{345\times 3600\sin.''};$$

and substituting 362,932 for Z, we find

$a =$ 20,855,000 feet nearly.

The method of deducing the ellipticity and dimensions of the earth which has now been explained, may be conveniently employed when the measured arcs are small; but when the arcs are considerable (and it is necessary that they should extend over several degrees, in order to give results deserving of confidence), we must employ the more accurate expression of the arc found in equation (7); that is to say, we must employ the whole arc measured, instead of the resulting length of a single degree. Equation (7), when reduced to numbers, takes the form

$$\mathrm{A} = am + aen\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10.)$$

in which m, n, and the arc A, are numbers determined by observation. Another arc will give a similar equation,

$$\mathrm{A}' = am' + aen',$$

and by combining the two equations we get

$$e = \frac{\mathrm{A}m' - \mathrm{A}'m}{\mathrm{A}'n - \mathrm{A}n'};\quad a = \frac{\mathrm{A}n' - \mathrm{A}'n}{mn' - m'n}\ldots\ldots\ldots\ldots\ldots\ldots(11.)$$

If the terrestrial meridian were a regular ellipse, the ellipticity deduced from two measured arcs would be the same at every latitude. But it is found that no two different measures that have yet been effected concur in giving exactly the same figure to the meridian. Hence it becomes necessary to seek the most probable mean among the different results. Each new measure affords a new equation of condition, of the form of equation (10); and as the number of unknown quantities remains the same, whatever may be the number of equations, recourse must be had to the method of least squares, or some of the other methods of combination employed by astronomers. In this way each individual measurement serves to correct the results given by the former ones.

6. *From the measured lengths of an arc of meridian, and an arc of parallel, to determine the ellipticity of the spheroid.*

Let z be the arc of meridian between the latitudes l and l', V the length of the arc of parallel in feet at the latitude L, and D the difference of longitude in seconds between its extreme points. From equation (5) we have

$$z = a\left\{1 - e + 3\,e\sin.^2\tfrac{1}{2}(l'+l)\right\}(l'-l)\sin.\,1'',$$

and from equation (8),

$$\mathrm{V} = a\,(1 + e + e\sin.^2\mathrm{L})\cos.\,\mathrm{L}\times\mathrm{D}\sin.\,1'',$$

whence

$$\frac{\mathrm{V}}{\cos.\,\mathrm{L}\times\mathrm{D}\sin.\,1''} - \frac{z}{(l'-l)\sin.\,1''}$$
$$= ae\left\{2 + \sin.^2\mathrm{L} - 3\sin.^2\tfrac{1}{2}(l'+l)\right\},$$

and, consequently,

$$e = \frac{\dfrac{\mathrm{V}}{\cos.\,\mathrm{L}\times\mathrm{D}\sin.\,1''} - \dfrac{z}{(l'-l)\sin.\,1''}}{a\left\{2 + \sin.^2\mathrm{L} - 3\sin.^2\tfrac{1}{2}(l'+l)\right\}}\ldots\ldots\ldots\ldots(12.)$$

When the two arcs have been measured at the same

Figure of the Earth.

of latitude, that is, when $L = \frac{1}{2}(l' + l)$, the denominator of this fraction becomes $a\,(2 - 2\,\sin.^2 L) = 2\,a\,\cos.^2 L$. This combination may be considered as giving a correct representation of the curvature at any particular place, or of the dimensions and eccentricity of the osculating spheroid at that place. But, speaking generally, the exact determination of the differences of longitude is attended with so much uncertainty, that the results obtained from the comparison of arcs of parallel, either with one another or with arcs of meridian, cannot be relied on with much confidence. It is consequently unnecessary to point out the equations to be employed in deducing the ellipticity from the comparison of two arcs of parallel.

We shall now proceed to apply the above formulas to the results of the principal geodetic measurements that have been executed in different countries. The following table contains twenty arcs of meridian, between the equator and 66° of north latitude; and as they have all been determined with the utmost attention to every circumstance which could be supposed to affect their accuracy, they may be regarded as decidedly the best elements we yet possess for the solution of the problem of the figure of the earth. We have excluded all the ancient arcs except that of Bouguer, and also some recent ones, where the locality was unfavourable. They are all reduced to the level of the sea. In reducing the foreign measures, the metre has been assumed (according to Captain Kater's determination) = 3·280899 feet, and the toise = 6·394596 feet, of Schuckburgh's scale. The original documents are given in the various works to which reference has been made in the first section of this article.

No.	Extremities of Arc.	Latitude.			Amplitude.			Length in English Feet.
	PERUVIAN ARC.							
1	Tarqui	— 3°	4′	30″·	3°	7′	3″·1	1,131,057
	Cotchesqui	+ 0	2	32·				
	1ST INDIAN ARC.							
2	Trivandeporum	+ 11	44	52·59	1	34	56·4	574,368
	Paudree	13	19	49·02				
	2D INDIAN ARCS.							
3	Punnæ	+ 8	9	32·51	2	50	10·5	1,029,171
4	Putchapollium	10	59	43·05	4	6	11·3	1,489,198
5	Namthabad	15	5	54·33	2	57	21·7	1,073,409
6	Daumergidda	18	3	16·07	3	2	35·9	1,105,499
7	Takal Khera	21	5	51·94	3	1	19·9	1,097,320
	Kulliampoor	24	7	11·85				
	MODERN FRENCH ARCS.							
8	Formentera	+ 38	39	56·11	2	41	50·5	982,247
9	Montjouy	41	21	46·58	1	51	7·7	674,623
10	Carcassone	43	12	54·31	2	57	48·2	1,079,706
11	Evaux	46	10	42·54	2	40	6·8	973,853
12	Pantheon	48	50	49·37	2	11	19·1	798,971
13	Dunkirk	51	2	8·50	0	26	31·5	161,412
	Greenwich	51	28	40·00				
	ENGLISH ARCS.							
14	Dunnose	+ 50	37	8·60	1	36	20·0	586,319
15	Arbury Hill	52	13	28·59	1	14	3·4	450,018
16	Clifton	53	27	31·99	1	6	49·7	406,516
	Burleigh Moor	54	34	21·70				
	HANOVERIAN ARC.							
17	Göttingen	+ 51	31	47·85	2	0	57·4	736,426
	Altona	53	32	45·27				
	RUSSIAN ARCS.							
18	Jacobstadt	+ 56	30	4·64	1	52	42·8	686,022
19	Dorpat	58	22	47·41	1	42	22·5	623,719
	Hochland	60	5	9·90				
	SVANBERG'S SWEDISH ARC.							
20	Mallörn	+ 65	31	31·06	1	37	20·3	593,278
	Pahtawara	67	8	51·41				

Substituting in equation (7) the values of $z' - z$, l, and l', for each of the arcs in the above table, we obtain the following equations of condition:

1. $a \times {\cdot}0544111 - ae \times {\cdot}05426 = 1131057$
2. $a \times {\cdot}0276169 - ae \times {\cdot}02371 = 574368$
3. $a \times {\cdot}0495037 - ae \times {\cdot}04536 = 1029171$
4. $a \times {\cdot}0716119 - ae \times {\cdot}06058 = 1489198$
5. $a \times {\cdot}0515924 - ae \times {\cdot}03891 = 1073409$
6. $a \times {\cdot}0531157 - ae \times {\cdot}03519 = 1105499$
7. $a \times {\cdot}0527472 - ae \times {\cdot}02933 = 1097320$
8. $a \times {\cdot}0470778 + ae \times {\cdot}01131 = 982247$
9. $a \times {\cdot}0323260 + ae \times {\cdot}01159 = 674623$
10. $a \times {\cdot}0517210 + ae \times {\cdot}02504 = 1079706$
11. $a \times {\cdot}0465751 + ae \times {\cdot}02940 = 973853$
12. $a \times {\cdot}0381990 + ae \times {\cdot}02893 = 798971$
13. $a \times {\cdot}0077158 + ae \times {\cdot}00636 = 161412$
14. $a \times {\cdot}0280221 + ae \times {\cdot}02335 = 586319$
15. $a \times {\cdot}0215422 + ae \times {\cdot}01900 = 450018$
16. $a \times {\cdot}0194397 + ae \times {\cdot}01875 = 406516$
17. $a \times {\cdot}0351849 + ae \times {\cdot}03132 = 736426$
18. $a \times {\cdot}0327868 + ae \times {\cdot}03708 = 686022$
19. $a \times {\cdot}0297797 + ae \times {\cdot}03618 = 623719$
20. $a \times {\cdot}0283097 + ae \times {\cdot}04293 = 593278$

From any two of these equations we may deduce values of a and e; but, as might be expected, the results are found to be very different according as different arcs are selected for comparison. We may also add any number of the equations together, for instance Nos. 3, 4, 5, 6, and 7, the sum of which forms the continuous arc measured in India by Colonel Lambton and Captain Everest: or Nos. 8, 9, 10, 11, and 12, which form the French arc from Dunkirk to Formentera. But as it is impossible to satisfy at once all the equations by any value whatever that can be assigned to a and e, in order to exclude all arbitrary hypotheses, it is necessary to suppose all the observations to have been alike good, and deduce values of a and e from a combination of the whole. The best method of effecting the combination is that of *minimum squares*, the principle of which is contained in the following rule: Multiply all the terms of each of the proposed equations by the co-efficient of a in that equation, taken with its proper sign, and make the sum of all the products equal to zero. This will give an equation in which the sum of the squares of the errors is a minimum in respect of a. Multiply then each equation by the co-efficient of ae in that equation, and make the sum of all the products $= 0$. This will give a second equation, in which the sum of the squares of the errors is a minimum in respect of ae. From the two equations thus obtained, the values of a and ae, and consequently e, are found in the usual manner. The operation is extremely laborious when the equations are numerous, but it is attended with no difficulty.

By combining the above twenty equations in the manner now described, M. Schmidt obtained the following results, which are given in No. 213 of Schumacher's *Astronomische Nachrichten*, p. 371; and they are unquestionably entitled to be regarded as the best determination of the magnitude and figure of the earth which has been found from the operations that have been undertaken up to the present time for the measurement of meridional arcs.

Radius of equator $= b = 20921665$ Eng. feet.

Radius of pole..... $= a = 20852394$

$$\text{Ellipticity} = e = \frac{b-a}{a} = \frac{1}{301{\cdot}02} = {\cdot}0032555$$

Degree at equator..... = 362732

Degree at latitude 45° = 364543·5

In order to discover how nearly the different measures agree with a spheroid having the dimensions now given, we shall compare the length of a degree, as given by each of the above twenty arcs, with its length, computed from these values of a and e at the same latitudes.

No.	Latitude of Middle Point.			Measured Length of Degree.	Computed Length of Degree.	Error in Measure.
1	— 1°	31′	0″	362,809	362,736	+ 73
2	12	32	21	362,988	362,905	+ 83
3	9	34	43	362,863	362,834	+ 29
4	13	2	54	362,873	362,919	— 46
5	16	34	42	363,125	363,029	+ 96
6	19	34	34	363,257	363,139	+ 118
7	22	36	32	363,084	363,268	— 184
8	40	0	52	364,152	364,233	— 81
9	42	17	21	364,239	364,376	— 137
10	44	41	48	364,347	364,528	— 181
11	47	30	46	364,962	364,706	+ 256
12	49	56	29	365,052	364,859	+ 193
13	51	15	24	365,116	364,940	+ 176
14	51	25	18	365,208	364,952	+ 256
15	52	50	30	364,625	365,036	— 411
16	54	0	56	365,002	365,109	— 107
17	52	32	17	365,301	365,019	+ 282
18	57	26	26	365,203	365,310	— 107
19	59	13	58	365,551	365,412	+ 139
20	66	20	11	365,697	365,777	— 80

From this table we see that the degrees increase gradually from the equator to the pole; but the increase is by no means regular. It occurs in some instances that the degrees appear to diminish on going northward; but these anomalies must be ascribed either to errors in the observations or to local irregularity of form or density. The most probable source of error is in the latitudes, first, on account of the difficulty of the observation to the requisite degree of accuracy; and, secondly, on account of the irregularities in the density of the exterior crust of the earth, which cause a deflexion of the plumb-line from the true zenith. Hence the longest arcs are the best; for the probable error in the determination of the difference of latitudes is the same whether the arcs are great or small. An error of 1″ in the latitude corresponds to about a hundred feet on the ground.

If we compare the degree found by some of the measures which have been rejected from the foregoing table, with the degree computed for the same latitudes, we shall find the errors or anomalies much greater.

Arcs.	Lat. of Middle Point.			Measured Length of Degree.	Computed Length of Degree.	Difference.
Lacaille's arc at Cape of Good Hope..........................	—33°	18′	30″	364,712	363,826	+ 886
North American arc, by Mason and Dixon....................	39	12	00	363,786	364,181	— 395
Roman arc, by Boscovich...	42	59	00	364,262	364,418	— 156
Piedmontese arc, by Plana and Carlini........................	44	57	30	368,242	364,543	+ 3699
Maupertuis' Swedish arc...	66	19	37	367,086	365,774	+ 1312

Two of these differences are considerably greater than any in the preceding table. Lacaille's arc corresponds to one in the northern hemisphere at a higher latitude by 11°, whence it has been inferred that the two hemispheres are not exactly similar. The measurement of Plana and Carlini appears to have been excellent; but both extremities of the arc were in the immediate vicinity of lofty mountain ranges, and the very great deviation from the mean result of the other measures can only be accounted for by the disturbing effects of local attraction. Maupertuis' arc was never reckoned of much value, as it was evident from the first that there was an error in the determination of the latitudes.

Taking the results of the four arcs of parallel mentioned before, and computing the corresponding degree from the formula $a \cos. l\,(1 + e + e \sin.^2 l)\; 3600 \sin. 1''$ (supposing a and e to have the same values as above), we get the following table:

Arcs of Parallel.	Latitude.	Measured Degree.	Computed Degree.	Difference.
Lacaille's arc across the mouth of the Rhone	43° 31′ 50″	266,345	265,154	+ 1191
Roy's arc from Beachy Head to Dunnose	50 44 24	232,331	231,542	+ 789
Arc from Dover to Falmouth	50 44 24	231,579	231,542	+ 37
Arc from Padua to Marennes	45 43 12	255,480	255,370	+ 110

It is remarkable that all these errors are affected with the same sign; and the circumstance might seem to strengthen a conclusion indicated by a comparison of the errors of the meridional arcs, namely, that the meridional curve is not exactly an ellipse, but protuberant between the latitudes of 40° and 52°; in consequence of which the degrees of meridian are shorter, and the degrees of parallel longer between those latitudes, than if the earth were a regular ellipsoid. There is no reason to infer that the meridians are not similar, or that the earth is not a solid of revolution.

The six partial arcs into which the whole arc from Marennes to Padua was divided, give the following results (*Connaissance des Tems*, 1829).

	Arcs.	Astronomical Amplitudes.	Length in Feet.	Length of Degree.
		h. m. sec.		
1	Marennes to St Preuil	0 3 48·99	244,123	255,865
2	St Preuil to Sauvagnac	0 6 23·09	407,429	255,248
3	Sauvagnac to Isson	0 6 51·39	437,493	255,228
4	Isson to Geneva	0 11 57·82	764,736	255,686
5	Geneva to Milan	0 12 9·57	776,646	255,486
6	Milan to Padua	0 10 45·38	686,549	255,308

The mean of these results, or the most probable value of the degree of parallel at the latitude of the stations (45° 43′ 12″), is 255,470 feet, exceeding the computed length only by a hundred feet; and the ellipticity which they indicate is $\frac{1}{282{\cdot}8}$. This is considerably greater than the ellipticity indicated by the measures of meridional arcs, but agrees pretty nearly with that which we shall see is given by the pendulum observations. The results, however, though valuable as confirming the results obtained by other methods, are not by any means worthy of the same confidence as those deduced from the measurement of meridional arcs.

We shall conclude this section with a re-statement of the dimensions of the earth, resulting from the principal measures of arcs of meridian.

		Feet.		Miles.
Equatorial diameter	=	41843330	=	7924·873
Polar diameter	=	41704788	=	7898·634
Difference of diameters, or polar compression	=	138542	=	26·239
Ratio of diameters	=	302·026	:	301·026

$$\text{Ellipticity} = \frac{b - a}{a} = \frac{1}{301{\cdot}026}$$

Length of degree at equator = 362732 feet.
Length of degree at lat. 45° = 364543·5 feet.

SECTION IV.

THEORETICAL INVESTIGATION OF THE FIGURE OF THE EARTH FROM THE LAWS OF HYDROSTATICS.

In attempting to deduce the figure of the earth from the general laws of hydrostatic equilibrium, we suppose the whole mass to have been originally fluid, or in such a state, that all its molecules were at liberty to obey the forces by which they are impelled. These forces are, 1*st*, the attraction of the molecules on one another, according to the Newtonian law; and, 2*dly*, the centrifugal force generated by the revolution of the whole mass about a fixed axis; and the problem is, to determine the form which such a body, under the influence of these forces, would ultimately take. In order to obtain a solution of the question thus generally enunciated, it is necessary to know, *a priori*, the attractions of the different parts of the fluid body on one another. But the attraction of its different parts depends on their mutual arrangement; that is to say, on the internal constitution of the body or the variations of its density, and also on its form. Of the density in the interior of the earth we know little; and its form is the very element we are seeking to determine. This mutual dependence of the attraction of the mass on its form, and of its form on its attraction, renders it necessary to have recourse to certain arbitrary assumptions respecting the primitive figure of the earth and its internal structure, in order to determine the relation of the forces with which its different parts attract each other, and thence assign its figure, and the variations of gravity at the different points of its surface.

A fluid mass whose particles are impelled by no other forces than those which result from their mutual attractions, would assume (it is natural to suppose) a spherical form. Such at least would be a figure of equilibrium; for the surface of the sphere being everywhere at right angles to the directions of the attracting forces, which in this case all pass through the centre of gravity, a particle placed on its surface would have no tendency to move along the surface in any direction. But if the mass is made to revolve, the rotation gives rise to an extraneous force, tending to cause every particle to recede from the axis, and which acts with an energy on each particle directly proportional to the distance of the particle from the axis. Hence the attraction of the mass on each particle, in the direction perpendicular to the axis of rotation, is diminished, and the diminution is greatest towards the equatorial parts, where the distance from the axis is greatest. In order, therefore, that the equilibrium may be restored, an accumulation of matter must take place about the equator, so that the mass will bulge out in that quarter, and become flattened at the poles, where the force of attraction is not counteracted. This consideration led Newton to suppose the figure of the earth to be that of an oblate spheroid, or the figure that is generated by the revolution of an ellipse about its shorter axis.

Before proceeding with the investigation, it will be proper to inquire what are the conditions necessary to ensure the equilibrium of a mass of fluid matter, the particles of which are acted on by their mutual attractions and the centrifugal force of rotation. Conceive the particles of a body A to be solicited by accelerating forces of any kind. Suppose dm (which may be regarded as a rectangular parallelepipedon, having its faces parallel to the planes of the co-ordinates) to be one of the molecules of the mass, and x, y, z, the co-ordinates of the solid angle nearest the origin; then, putting $k =$ the density of the mass, we shall have $dm = k \,.\, dx\, dy\, dz$. Let X, Y, Z be the accelerating forces acting on dm in the direction parallel to the respective axes of the co-ordinates, then the motive forces in the direction of the same axes will be respectively $\mathrm{X}dm$, $\mathrm{Y}dm$, $\mathrm{Z}dm$.

Now let $p =$ the pressure in the direction of the axis of x, referred to the unit of surface; then $p \,.\, dydz$ is the whole pressure on the face $dydz$ of the element dm. But p may be regarded as a function of x, y, z; therefore at the point whose co-ordinates are $x + dx, y, z$, the pressure on the unit of surface is $p + \frac{dp}{dx}dx$, and consequently the whole pressure on the face of dm opposite to $dxdy$ is $\left(p + \frac{dp}{dx}dx\right) dydz$. The particle dm is thus urged in the direction of the axis of x by the two forces $p \,.\, dydz$ and $\left(p + \frac{dp}{dx}dx\right) dydz$, or by a force equal to their difference, namely, $\frac{dp}{dx}dxdydz$. In order, therefore, that dm may remain at rest, this last force or pressure must be exactly balanced by the motive force acting in the direction of the same axis; that is to say, we must have $\frac{dp}{dx}dxdydz = \mathrm{X}dm$. In the same manner, we must have $\frac{dp}{dy}dxdydz = \mathrm{Y}dm$, and $\frac{dp}{dz}dxdydz = \mathrm{Z}dm$; whence, since $dm = k \,.\, dx\, dy\, dz$, we deduce

$$\frac{dp}{dx} = k\mathrm{X},\ \frac{dp}{dy} = k\mathrm{Y},\ \frac{dp}{dz} = k\mathrm{Z}\ldots\ldots\ldots\ldots(a).$$

Let the first of these equations be multiplied by dx, the second by dy, and the third by dz, the sum of the products gives

$$dp = k\,(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz)\ldots\ldots\ldots\ldots\ldots(b).$$

The first member of this equation being an exact differential, it is necessary, in order that the equilibrium be possible, that the second member be an exact differential likewise. This, therefore, is a condition which must be satisfied.

At the surface of the mass the pressure p vanishes, and equation (b) becomes

$$0 = k\,(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz),$$

which expresses that the resultant of the three forces X, Y, Z, is perpendicular to the surface.

If the fluid is homogeneous, the density k is constant, and may be represented by unit. In this case equation (b) becomes

$$dp = \mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz,$$

and the equation of the surface is

$$\int(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) = \text{constant}.$$

It will be remarked that this last equation does not belong merely to the exterior surface or to the homogeneous fluid: by giving a different value to the constant it will form the equation of any surface in the interior of a mass of heterogeneous fluid, at every point of which the pressure or the density is the same. For let the second member of equation (b) be a complete differential, and equal to kdf. We have then $dp = kdf$, whence k is necessarily a function of p and f. But on integrating the equation, f will be given in a function of p, consequently k must be a function of p. When therefore k is constant, p must be constant, or $dp = 0$; hence

$$\int(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) = \text{constant}.$$

The different surfaces defined by this equation all possess the common property of intersecting at every point the resultant of the accelerating forces X, Y, Z at right angles; hence they are denominated *level surfaces.*

It follows, therefore, that when the above equation is satisfied, two conditions necessary to the equilibrium are fulfilled; namely, that the resultant of all the forces urging any particle in the interior of the mass is perpendicular to the level surface passing through that particle; and that the force acting on any particle of the surface is perpendicular to the surface. When the fluid is homogeneous, or the density equal throughout the mass, the first of these conditions is always satisfied, and the second is of itself sufficient. Writers on this subject have therefore in general considered that all the conditions necessary to ensure the equilibrium of a fluid mass, whether homogeneous or heterogeneous, revolving about a fixed axis, are comprehended in the single equation

$$\int(\mathrm{X}dx + \mathrm{Y}dy + \mathrm{Z}dz) = \text{constant};$$

and this is the view which has been taken of the question by Clairaut, D'Alembert, Lagrange, Laplace, Legendre, and Poisson. It has, however, been demonstrated by Mr Ivory, in an elaborate paper in the *Philosophical Transactions for* 1824, that when, as in the case of the earth, a mutual attraction exists among the constituent molecules of the mass, another condition must be fulfilled; and that the equilibrium will not necessarily take place, unless the figure of the mass is such, that any "interior body of the fluid, bounded by a level surface, be *in equili-*

brio with respect to the attraction of all the exterior matter." Hence, in addition to the equation derived from the principle of equal pressure in all directions, a second equation must be satisfied, in virtue of which every level stratum must possess such a figure as to attract all particles in the inside with equal force in opposite directions. Without having regard to this condition, the problem cannot be completely solved. (See also *Philosophical Magazine* for April 1825.)

Within the limits to which the present article must necessarily be confined, it would be in vain to attempt to give a general solution of this very intricate problem. We shall therefore content ourselves with demonstrating that all the conditions of equilibrium will be satisfied, if the figure of the earth (assumed to be fluid) is that of a spheroid of revolution of small ellipticity. We shall, first, suppose the fluid to be homogeneous; and, secondly, that its density is variable.

Prop. I.—A particle placed anywhere within a hollow solid of homogeneous matter, generated by the annular space comprised between two similar and similarly situated concentric ellipses revolving about their common axis, is attracted by the solid equally in all directions.

For let p (fig. 11) be such a particle, and ab any straight line passing through p, meeting the exterior surface in a and b, and the interior in c and d; then if ab be bisected in e, cd will also be bisected in e, because the figures are similar and similarly situated. Therefore $ac = db$. Now conceive ab to be the axis of two opposite pyramids having their vertices at p, and terminated by the surface at a and b, and let mn be an infinitely thin slice of the pyramid ab, formed by surfaces parallel to that of the given spheroid. The attraction of mn on p is directly as the surface mn and inversely as pm^2; but the surface mn is proportional to pm^2; therefore the attraction of p on the pyramidal slice mn is constant; hence the attraction of p on the whole frustum between a and c is proportional to the number of such slices, or to ac. In the same manner the attraction of p on the frustum between d and b is proportional to db. But $ac = db$; therefore p is attracted equally in both directions. The same thing being true of all other pyramids which have their vertices at p, it follows that the particle p is attracted equally in all directions, or remains at rest.

This property, which is true also of the sphere, and forms one of the necessary conditions of equilibrium, was first demonstrated by Newton in the *Principia*.

Prop. II.—To find the ratio of the axes of a homogeneous spheroid of revolution, when a fluid column from the equator to the centre balances the column from the pole to the centre, the spheroid being supposed to revolve about its minor axis, and its particles to attract one another with forces varying in the inverse ratio of their mutual distances.

Let PQ (fig. 12) be a meridian of the spheroid, of which the centre is C. Let us assume in the following propositions,

$\mathrm{P} =$ the attraction of the spheroid at the pole, or gravity,
$\mathrm{Q} =$ the attraction at the equator,
$\varphi =$ the centrifugal force at the equator,
$\mathrm{Q}' = \mathrm{Q} - \varphi$ the gravitation at the equator, or the attraction of the spheroid there diminished by the centrifugal force.

Let also

$a =$ CP half the polar axis,
$b =$ CQ the radius of the equator.

In CP take any point E, and make $\mathrm{CE} = x$. It is demonstrated in the article Attraction (art. 8), that the force with which a particle at E is attracted towards C, is to that with which a particle at P is attracted in the same direction as CE to CP, or x to a; therefore the force at $\mathrm{E} = \mathrm{P}\cdot\frac{x}{a}$. Now if we suppose the area of a section of the column perpendicular to the axis $= 1$, the mass of the element of the column will be $1 \times dx = dx$, and its pressure will consequently be $\mathrm{P}\frac{x}{a}dx$. Let this quantity be represented by du. On integrating, and observing that while x increases u diminishes, we find

$$u = \text{const.} - \mathrm{P}\cdot\frac{x^2}{2a}.$$

At the surface $u = 0$ and $x = a$; therefore

$$0 = \text{const.} - \mathrm{P}\cdot\frac{a^2}{2a};$$

whence, by subtraction, $u = \mathrm{P}\cdot\frac{a^2 - x^2}{2a}$,

and consequently at the centre, where $x = 0$, $u = \mathrm{P}\cdot\frac{a}{2}$.

In like manner, if in CQ we take a point F, and make $\mathrm{CF} = y$, the force at F resulting from the attraction of the spheroid will be $\mathrm{Q}\cdot\frac{y}{b}$. But the centrifugal force at F is to that at Q as CF to CQ, or as y to b; therefore the centrifugal force at $\mathrm{F} = \varphi\cdot\frac{y}{b}$. Hence the force with which a particle at F is attracted towards the centre is $(\mathrm{Q} - \varphi)\frac{y}{b} = \mathrm{Q}'\frac{y}{b}$, and the pressure of the element of the column $= \mathrm{Q}'\frac{y}{b}dy$. Putting this $= du'$, and integrating as before, we find, at the centre, $u' = \mathrm{Q}'\frac{b}{2}$. But, by hypothesis, at the centre $u' = u$; therefore $\mathrm{P}\frac{a}{2} = \mathrm{Q}'\frac{b}{2}$, whence $\mathrm{P} : \mathrm{Q}' = b : a$; that is to say, the attraction at the pole is to the gravitation at the equator as the radius of the equator to the radius of the pole.

Prop. III.—If the radius of the equator is to the radius of the pole as the attraction at the pole is to the gravitation at the equator, the resultant of all the forces which urge a particle situated any where on the surface of the spheroid is perpendicular to the surface.

Let D (fig. 10) be the particle, and PDQ the meridian passing through it. As the plane of the meridian divides the solid into two parts exactly alike in every respect, it is obvious that the particle can have no tendency to move out of that plane; we shall therefore only consider the direction of the force urging it in the plane of the meridian. Let DE be perpendicular to CP, and DF to CQ; and make $\mathrm{CE} = x$, $\mathrm{CF} = y$. It is demonstrated in the article Attraction (21 and 22), that the force which attracts D in the direction DF, perpendicular to the plane of the equator, is to the force at the pole as DF to CP, or as $x : a$; and that the force attracting D in the direction DE perpendicular to the axis is to the attraction at Q as DE to CQ, or as $y : b$; but the centrifugal force at D, which also acts in the direction DE, is to that at Q as DE to CQ; therefore, taking X to represent the whole force at D in the direction parallel to the axis, and Y that in the direction perpendicular to the axis, we have

$$\mathrm{X} : \mathrm{P} = x : a, \text{ and } \mathrm{Y} : \mathrm{Q}' = y : b,$$

Figure of the Earth.

whence $X = P\frac{x}{a}$, $Y = Q'\frac{y}{b}$. In QC take the point N such that FN : FD = Y : X; then FN : FD $= Q'\frac{y}{b} : P\frac{x}{a}$, or FN · x : FD · y = Q$'a$: Pb, whence, since FD = x, and FC = y, FN : FC = Q$'a$: Pb. But by hypothesis Q$'$: P = $a : b$, therefore FN : FC = $a^2 : b^2$, whence by the well-known properties of the ellipse FN is the subnormal, and DN the normal or perpendicular to the surface of the spheroid at D.

Corollary. If the attraction at the pole is represented by CP, then the force at any point D on the surface, in the direction perpendicular to the surface, is proportional to DN the normal passing through D. It is also proportional to DM (the normal produced till it meets the axis); for, by conic sections, DM : DN = $b^2 : a^2$; that is, DM has to DN a constant ratio.

The proposition which has now been demonstrated is sufficient for the equilibrium of a homogeneous fluid mass revolving about an axis. It may, however, be shown directly, that when the above condition is fulfilled, any particle in the interior of the mass will be equally urged in all directions, or will remain at rest. Thus:—

Prop. IV.—If the radius of the equator is to the radius of the pole as the attracting force at the pole is to gravitation at the equator, the pressure which any point D in the interior of the spheroid sustains from the fluid in canals of any form, extending from that point to the surface, is the same for every canal.

Let DD$'d$ (fig. 13) be a canal drawn from any point D in the interior of the spheroid to D$'$ and d in the surface. Let x', y', z' be the rectangular co-ordinates of D, and x'', y'', z'' those of D$'$. Take F and f, any two points in the canal indefinitely near each other, and let x, y, z be the co-ordinates of F; then $x + dx$, $y + dy$, and $z + dz$ are those of f. Now X, Y, and Z being the resultants of the forces acting on F in the directions of the co-ordinates, the forces X, Y, Z will be reduced to the direction of the canal at F by multiplying them respectively by the cosines of the angles which that direction makes with the axes, that is, by $\frac{dx}{du}$, $\frac{dy}{du}$, $\frac{dz}{du}$, (u representing the canal). Hence the accelerating force acting on F in the direction of the canal is $X\frac{dx}{du} + Y\frac{dy}{du} + Z\frac{dz}{du}$; and supposing the area of a section of the canal = 1, the pressure produced by the action of this force on the fluid contained in the portion of the canal Ff is $du\left(X\frac{dx}{du} + Y\frac{dy}{du} + Z\frac{dz}{du}\right)$. But, by what has been demonstrated in the article Attraction (9), $X = P\frac{x}{a}$, $Y = Q'\frac{y}{b}$, $Z = Q'\frac{z}{b}$; therefore, denoting the whole pressure of the canal on F by p, and observing that p diminishes as F is nearer the surface, we have

$$-dp = du\left(P\frac{x}{a}\cdot\frac{dx}{du} + Q'\frac{y}{b}\cdot\frac{dy}{du} + Q'\frac{z}{b}\frac{dz}{du}\right),$$

and integrating,

$$p = \text{const.} - P\frac{x^2}{2a} - Q'\frac{y^2 + z^2}{2b}$$

At the point D this becomes

$$p = \text{const.} - P\frac{x'^2}{2a} - Q'\frac{y'^2 + z'^2}{2b},$$

and at D$'$, where $p = 0$,

$$0 = \text{const.} - P\frac{x''^2}{2a} - Q'\frac{y''^2 + z''}{2b};$$

therefore, by subtraction,

$$p = P\frac{x''^2 - x'^2}{2a} + Q'\frac{y''^2 - y'^2 + z''^2 - z'^2}{2b}.$$

Now the equation of the surface of the spheroid gives

$$x''^2 = \frac{a^2}{b^2}\left\{b^2 - (y''^2 + z''^2)\right\},$$

whence

$$P\frac{x''^2}{2a} = P\frac{a}{2} - P\frac{a(y''^2 + z''^2)}{2b^2},$$

and, by hypothesis, P : Q$'$ = $b : a$, or Pa = Q$'b$; therefore

$$P\frac{x''^2}{2a} = P\frac{a}{2} - Q'\frac{y''^2 + z''^2}{2b};$$

and on substituting this in the above expression of the value of p, we get, finally,

$$p = P\frac{a}{2} - P\frac{x'^2}{2a} - Q'\frac{y'^2 + z'^2}{2b}.$$

This equation being independent of the form of the canal, and of the situation of the point D$'$, will necessarily be the same for every canal extending from D to the surface of the spheroid; consequently the point D sustains the same pressure in all directions.

From what has now been demonstrated, it appears that a fluid spheroid of uniform density, revolving about its lesser axis, and whose particles attract one another with forces varying in the inverse ratio of the distances, will be *in equilibrio* when the gravity at the pole is to the gravity at the equator diminished by the centrifugal force there, as the equatorial axis to the polar axis. The equation of equilibrium of such a spheroid is therefore Pa=Q$'b$; and from this we shall now proceed to determine the ratio of the axes, or of $a : b$, corresponding to a given velocity of rotation.

Let ε be the eccentricity, that is, let $\varepsilon^2 = \frac{b^2 - a^2}{a^2}$, whence $b^2 = a^2(1 + \varepsilon^2)$. It is demonstrated in the article Attraction (23 and 24), that

$$P = 4\pi a\frac{1 + \varepsilon^2}{\varepsilon^3}(\varepsilon - \text{arc tan. } \varepsilon)$$

$$Q = (Q' + \varphi) = 2\pi b\frac{1 + \varepsilon^2}{\varepsilon^3}\left(\text{arc tan. } \varepsilon - \frac{\varepsilon}{1 + \varepsilon^2}\right),$$

the density of the mass being 1, and π the semicircumference of a circle whose radius is unit. Now if t denote the time of a revolution, we shall have, from the theory of central forces, $\varphi = \frac{4\pi^2}{t^2}b$; and making $\frac{\pi}{t^2} = m$, we get $\varphi = 4\pi bm$, whence

$$Q' = 2\pi b\left\{\frac{1 + \varepsilon^2}{\varepsilon^3}\left(\text{arc tan. } \varepsilon - \frac{\varepsilon}{1 + \varepsilon^2}\right) - 2m\right\}.$$

Substituting these values of P and Q$'$ in the equation Pa = Q$'b$, it becomes

$$4\pi a^2\frac{1 + \varepsilon^2}{\varepsilon^3}(\varepsilon - \text{arc tan. } \varepsilon) =$$

$$2\pi b^2\left\{\frac{1 + \varepsilon^2}{\varepsilon^3}\left(\text{arc tan. } \varepsilon - \frac{\varepsilon}{1 + \varepsilon^2}\right) - 2m\right\};$$

whence, putting $a^2(1 + \varepsilon^2)$ instead of b^2, and neglecting the common factors, we get

$$\text{arc tan. } \varepsilon = \frac{3\varepsilon + 2m\varepsilon^3}{3 + \varepsilon^2}\text{..................(1).}$$

In order to discover whether this equation, which is transcendental, has a real root, or how many, we may put

$$\beta = \frac{3\varepsilon + 2m\varepsilon^3}{3 + \varepsilon^2} - \text{arc tan. } \varepsilon\text{............(2),}$$

f and suppose the curve to be described, of which ε is the abscissa, and β the ordinate. This curve will evidently cut the axis at the origin of the co-ordinates; for when $\varepsilon = 0$, we have also $\beta = 0$; but the root $\varepsilon = 0$ has no concern with the question; for the velocity, and consequently ε, is supposed to be a real quantity. By changing the sign of ε, the value of β undergoes no alteration, whence the curve has two equal and similar branches on opposite sides of the origin; we need therefore attend only to the positive values of ε. If then we suppose ε to increase from nothing to infinity, the value of β will begin and end with being positive, whence between these two values of ε the curve will either not cut the axis at all, or cut it an even number of times; or, which is the same thing, the equation has either no roots, or an equal number.

To find the values of ε corresponding to the greatest and least values of β, we must make $d\beta = 0$. Differentiating equation (2), we get, after arranging the terms,

$$\frac{d\beta}{d\varepsilon} = \frac{2\varepsilon^2\{m\varepsilon^4 + (10m - 2)\varepsilon^2 + 9m\}}{(1+\varepsilon^2)(3+\varepsilon^2)^2};$$

whence, making $d\beta = 0$,

$$m\varepsilon^4 + (10m - 2)\varepsilon^2 + 9m = 0 \ldots\ldots\ldots\ldots\ldots (3),$$

the two roots of which are

$$e^2 = 5 - \frac{1}{m} \pm \sqrt{\left(5 - \frac{1}{m}\right) - 9}.$$

Since these are the only roots of equation (3), it follows that there can be only one maximum and one minimum value of the ordinate β on each side of the origin of the abscissa. Hence we infer that the curve intersects the positive abscissa only in two points exclusive of the origin; so that there are two, and only two, real and positive roots of the equation (1). Thus there are two forms of the oblate spheroid, which, for a given velocity of rotation, satisfy the condition of equilibrium; a curious result, which was first made known by Legendre.

The limits within which the roots of equation (1) are possible will be obtained by determining the values of ε and m at the point where the curve touches the axis of the abscissa without cutting it. At this point $\beta = 0$, and $d\beta = 0$. When $d\beta = 0$, equation (3) gives

$$m = \frac{2\varepsilon^2}{\varepsilon^4 + 10\varepsilon^2 + 9} = \frac{2\varepsilon^2}{(1+\varepsilon^2)(9+\varepsilon^2)} \ldots\ldots\ldots (4);$$

substituting this in (2), and making $\beta = 0$, we get, after reduction,

$$\text{arc tan. } \varepsilon = \frac{7\varepsilon^5 + 30\varepsilon^3 + 27\varepsilon}{(3+\varepsilon^2)(1+\varepsilon^2)(9+\varepsilon^2)},$$

or, dividing the terms by $(3 + \varepsilon^2)$,

$$\text{arc tan. } \varepsilon = \frac{7\varepsilon^3 + 9\varepsilon}{(1+\varepsilon^2)(9+\varepsilon^2)};$$

an equation which can have only one positive root besides $\varepsilon = 0$. On solving it by approximation we easily find, on a few trials,

$$\varepsilon = 2{\cdot}5292;$$

whence, from equation (4), the corresponding value of m is

$$m = 0{\cdot}11234.$$

From this we conclude that, when the value of m is smaller than 0·11234, the equation (1) has two unequal positive roots; that when m is equal to this number, the two roots become equal, or the two intersections of the curve with the axis pass into a contact; and that when m is greater than 0·11234, equation (1) has no real roots, or the equilibrium is impossible.

When the eccentricity ε is a very small fraction, as in the case of the earth, the values of the quantities denoted by P and Q may be developed in series proceeding according to the powers of ε, and converging rapidly. Because (see ALGEBRA, sect. XXV. (H 2)

$$\text{arc tan. } \varepsilon = \varepsilon - \frac{\varepsilon^3}{3} + \frac{\varepsilon^5}{5} -, \&c.$$

and because

$$\frac{\varepsilon^2}{1+\varepsilon^5} = \varepsilon - \varepsilon^3 + \varepsilon^5 -, \&c.$$

the preceding expression for P becomes

$$P = 4\pi a \,.\, \frac{1+\varepsilon^2}{\varepsilon^3}\left(\frac{\varepsilon^3}{3} - \frac{\varepsilon}{5} +, \&c.\right);$$

whence, on multiplying, and rejecting all terms involving higher powers of ε than the square,

$$P = 4\pi a\left(\frac{1}{3} + \frac{2}{15}\varepsilon^2\right) = \frac{4\pi a}{3}\left(1 + \frac{2}{5}\varepsilon^2\right).$$

Making the same substitutions in the value of Q, we find

$$Q = 2\pi b\,\frac{1+\varepsilon^2}{\varepsilon^3}\left(\frac{2}{3}\varepsilon^3 - \frac{4}{5}\varepsilon^5 +, \&c.\right),$$

and multiplying as before,

$$Q = 2\pi b\left(\frac{2}{3} - \frac{2}{15}\varepsilon^2\right) = \frac{4\pi b}{3}\left(1 - \frac{1}{5}\varepsilon^2\right).$$

Now, if instead of ε we introduce the ellipticity e, and make $e = \frac{b-a}{a}$, we shall have $b = a(1+e)$. But we have already assumed $b^2 = a^2(1+\varepsilon^2)$; whence $1 + e = \sqrt{1+\varepsilon^2}$; and on rejecting the second and all the higher powers of e (which may be done because e is supposed to be a very small fraction), we have $1 + 2e = 1 + \varepsilon^2$, and consequently $2e = \varepsilon^2$. Substituting this in the above formulas, and observing that $b = a(1+e)$, we get

$$P = \frac{4\pi a}{3}\left(1 + \frac{4}{5}e\right); \quad Q = \frac{4\pi a}{3}\left(1 + \frac{3}{5}e\right);$$

and since $\varphi = 4\pi bm = 4\pi a(1+e)m = 4\pi am$ (for m and e being both very small fractions, their product me may be neglected), we have also

$$Q' = Q - \varphi = \frac{4\pi a}{3}\left(1 + \frac{3}{5}e - 3m\right).$$

Substituting these values of P and Q′ in the equation of equilibrium, $Pa = Q'b = Q'a(1+e)$, there results

$$1 + \frac{4}{5}e = (1+e)\left(1 + \frac{3}{5}e - 3m\right);$$

whence, rejecting terms multiplied by e^2 and em, we find

$$e = \frac{15}{4}m.$$

The ratio of the centrifugal force to gravitation at the equator is $\frac{\varphi}{Q}$, or $\frac{3m}{1 + \frac{3}{5}e - 3m} = 3m$; hence $e = \frac{5}{4} \cdot \frac{\varphi}{Q}$; that is to say, the ellipticity of a homogeneous spheroid revolving about an axis, and whose form does not differ greatly from that of a sphere, is equal to the fraction formed by dividing five times the centrifugal force at the equator by four times the gravitation at the equator. By comparing the length of the arc described by a point on the earth's surface in a second of time, with the descent of falling bodies, Newton found this ratio in the case of the earth to be $\frac{1}{289}$, whence $m = \frac{1}{3 \times 289} = \frac{1}{867}$, and consequently $e = \frac{15}{4} \times \frac{1}{3 \times 289} = \frac{1}{231}$, so that, supposing the earth to be homogeneous, the ratio of its polar to its equatorial axis ought to be 230 to 231 very nearly.

The ellipticity deduced from the actual measurements of degrees, as well as from the variations of gravity indicated by pendulum observations, is considerably less than $\frac{1}{231}$; consequently the earth is not homogeneous.

In what precedes, we have supposed generally $m = \frac{\pi}{t^2}$, and found for the limit which m cannot exceed, $m = 0{\cdot}11234$. Let m' be what m becomes in the case of the earth, and t' be the time (expressed in parts of a mean solar day) in which the earth makes one revolution about its axis; t being the time in which a spheroid of the same mean density as the earth would make a revolution when $m = 0{\cdot}11234$. We have then $m' = \frac{\pi}{t'^2}$, whence $m' : m = t^2 : t'^2$, whence $t = t'\sqrt{\frac{m'}{m}}$. But $t' = 23$ h. 56 m. 4 sec. $= {\cdot}99727$ day; and we have already found $m' = \frac{1}{867}$; therefore $t = {\cdot}99727 \sqrt{\frac{1}{867 \times 0{\cdot}11234}} = 0{\cdot}1009$ day $= 2$ hours 25 minutes 26 seconds. Hence a fluid mass of the same density as the earth could not be in equilibrium with the figure of an ellipsoid of revolution if its time of rotation were less than 2 h. 25 m. 26 sec. If the time of rotation is greater, there are two elliptic spheroids, and not more, which, with the same velocity of rotation, give a figure of equilibrium.

Hitherto we have considered only one of the roots of equation (1), and seen that it gives 230 : 231 as the ratio of the polar to the equatorial axis. Let us now inquire into the value of the other root.

As the value of ε^2 in the former case was very small, it will now be large; we may therefore proceed as follows: The identical equation

$$\text{arc tan. } \varepsilon = \frac{1}{2}\pi - \text{arc tan.} \frac{1}{\varepsilon}$$

gives

$$\text{arc tan. } \varepsilon = \frac{1}{2}\pi - \frac{1}{\varepsilon} + \frac{1}{3\varepsilon^2} - \frac{1}{5\varepsilon^5} +, \&c.$$

whence equation (1) becomes

$$\frac{3\varepsilon + 2m\varepsilon^3}{3\,\varepsilon^2} = \frac{1}{2}\pi - \frac{1}{\varepsilon} + \frac{1}{3\varepsilon^2} - \frac{1}{5\varepsilon^5} +, \&c.$$

Reverting this series, in order to find ε in a series proceeding by the powers of m, we get

$$\varepsilon = \frac{\pi}{4m} - \frac{8}{\pi} + \frac{12m}{\pi}\left(1 - \frac{64}{3\pi^2}\right) +, \&c.$$

or

$$\varepsilon = {\cdot}785398\,\frac{1}{m} - 2{\cdot}546479 - 4{\cdot}436656\,m.$$

Relatively to the earth, it has been seen that $m = \frac{1}{867}$; by substituting which in the above equation, it gives $\varepsilon = 680$ nearly; so that $\sqrt{1 + \varepsilon^2}$, the ratio of the equatorial to the polar axis, is 680 : 1. In this case the spheroid is extremely flattened.

In the preceding propositions it has been demonstrated that a fluid mass of uniform density revolving about a fixed axis will be *in equilibrio*, if its form is that of an oblate spheroid, provided the velocity of rotation does not exceed a certain limit, which has been ascertained. But it has been remarked, that if the same relation exists between the attraction and the centrifugal force as exists in the case of the earth, the ellipticity of such a spheroid would be different from the actual ellipticity of the earth, as determined by observation. It follows that the terrestrial spheroid must be heterogeneous, or of variable density; and this supposition is rendered more probable by what is otherwise known of the nature of the earth. The difficulties of the problem are however greatly increased in the case of a heterogeneous fluid; indeed it is only brought within the power of analysis by assuming that the form of the revolving mass differs very little from that of a sphere, and that it is regularly composed of concentric layers, increasing in density from the surface towards the centre, according to a determinate law. Admitting these assumptions, it may be demonstrated that the oblate spheroid of revolution is in this case also a figure of equilibrium.

The demonstration will be greatly simplified by means of the two following propositions respecting the attraction of homogeneous spheroids of small ellipticity, and which are easily deduced from the properties demonstrated in the article ATTRACTION.

PROP. V.—To find the measure of the attractive forces that urge a particle situated any where within or in the surface of a homogeneous oblate spheroid of revolution, in the directions parallel and perpendicular to the axis, the ellipticity being small.

Let D be the particle, x and y its rectangular co-ordinates (x being taken along the axis, and y perpendicular to the axis, in the meridional plane passing through D); let also X and Y denote the attractive forces soliciting the particle in those directions, and $k =$ the density of the spheroid.

By ATTRACTION (25), $\mathrm{P} : \mathrm{X} = a : x$, and $\mathrm{Q} : \mathrm{Y} = b : y$; therefore $\mathrm{X} = \mathrm{P}\frac{x}{a}$ and $\mathrm{Y} = \mathrm{Q}\frac{y}{b}$. But it has been already shown, that when the elipticity is small,

$$\mathrm{P} = \frac{4\pi}{3}a\left(1 + \frac{4}{5}e\right),\ \mathrm{Q} = \frac{4\pi}{3}a\left(1 + \frac{3}{5}e\right),$$

therefore

$$\mathrm{X} = \frac{4\pi}{3}x\left(1 + \frac{4}{5}e\right);\ \mathrm{Y} = \frac{4\pi}{3}\frac{a}{b}y\left(1 + \frac{3}{5}e\right).$$

Introducing the density k, to which the attraction is directly proportional, and observing that $\frac{a}{b} = \frac{1}{1+e}$, these expressions become

$$\mathrm{X} = \frac{4\pi}{3}kx\left(1 + \frac{4}{5}e\right);\ \mathrm{Y} = \frac{4\pi}{3}ky\left(1 - \frac{2}{5}e\right).$$

PROP. VI.—To find the measure of the forces with which an oblate spheroid, whose ellipticity is small, attracts a particle situated any where without it, in the direction parallel to the axis, and in the direction perpendicular to the axis, the density being uniform.

Let PQ (fig. 14) be the given spheroid, of which the axes are a and b, D the given point without the spheroid, and x' y' the co-ordinates of D. From the two assumed equations $b'^2 - a'^2 = b^2 - a^2$, and $\frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} = 1$, find a' and b', and conceive another spheroid P′Q′ to be described whose polar and equatorial semidiameters are respectively a' and b', whose centre coincides with that of the given spheroid, and which has its equator in the same plane. The surface of this spheroid, in consequence of the equation $\frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} = 1$, will necessarily pass through the point D. Make $x = \frac{ax'}{a'}$, $y = \frac{by'}{b'}$; then, by what is demonstrated in Attraction (26), the point D′, whose co-ordinates are x and y, is in the surface of the given spheroid PQ; and the attraction of the spheroid PQ on a particle at D is to the attraction of the spheroid P′Q′ on the point D′, as $b^2 : b'^2$ in the direction perpendicular to the equator, and as $ab : a'b'$ in the direction perpendicular to a plane passing through the axis. If, therefore, we denote by X and Y the attractions of the given spheroid PQ on D, and by X′ and Y′ those of the spheroid P′Q′ on D′, in the directions of the co-ordinates x and y respectively, we shall have

$$\mathrm{X} : \mathrm{X}' = b^2 : b'^2, \text{ and } \mathrm{Y} : \mathrm{Y}' = ab : a'b',$$

consequently

$$\mathrm{X} = \frac{b^2}{b'^2}\mathrm{X}, \ \mathrm{Y} = \frac{ab}{a'b'}\mathrm{Y}'.$$

But by the last proposition,

$$\mathrm{X}' = \frac{4\pi}{3} kx \left(1 + \frac{4}{5}e'\right), \ \mathrm{Y}' = \frac{4\pi}{3} ky \left(1 - \frac{2}{5}e'\right)$$

(e' being the ellipticity of the spheroid P′Q′p'); therefore

$$\mathrm{X} = \frac{4\pi}{3} \frac{b^2}{b'^2} k \left(1 + \frac{4}{5}e'\right) x, \ \mathrm{Y} = \frac{4\pi}{3} \frac{ab}{a'b'} k \left(1 - \frac{2}{5}e'\right) y;$$

and, on substituting for x and y their values $\frac{a}{a'}x'$ and $\frac{b}{b'}y'$, we have

$$\mathrm{X} = \frac{4\pi}{3} \frac{ab^2}{a'b'^2} k \left(1 + \frac{4}{5}e\right) x'; \ \mathrm{Y} = \frac{4\pi}{3} \frac{ab^2}{a'b'^2} k \left(1 - \frac{2}{5}e\right) y'.$$

We must now eliminate from these equations the quantities a', b', and e', by means of the three equations of condition $\frac{x'^2}{a'^2} + \frac{y'^2}{b'^2} = 1$, $b'^2 - a'^2 = b^2 - a^2$, and $b' = a'(1 + e')$. In order to abridge, let r = CD, the distance of D from the centre of the spheroid, and θ = the angle DCP. We have then $x = r \cos. \theta$, $y = r \sin. \theta$, and the first of the above equations becomes $r^2 (b'^2 \cos.^2 \theta + a'^2 \sin.^2 \theta) = a'^2, b'^2$, which, since $b' = a'(1 + e')$, and consequently $b'^2 = a'^2 (1 + 2e')$, reduces to $r^2 (1 + 2e' \cos.^2 \theta) = a'^2 (1 + 2e')$. On dividing by $1 + 2e'$, and neglecting terms multiplied by e^2, this gives $a'^2 = r^2 (1 - 2e' \sin.^2 \theta)$, and consequently $a'^2 e' = r^2 e'$.

But $b'^2 = a'^2 (1 + 2e')$, therefore $b'^2 - a'^2 = 2a'^2 e'$; and in like manner, $b^2 - a^2 = 2a^2 e$; whence, by reason of $b'^2 - a'^2 = b^2 - a^2$, we have $a'^2 e' = a^2 e$; consequently $a^2 e = r^2 e'$, and $e' = \frac{a^2}{r^2} e$. Substituting this value of e' in the equation $a'^2 = r^2 (1 - 2e' \sin.^2 \theta)$, we get $a'^2 = r^2 - 2a^2 e \sin.^2 \theta$; whence, neglecting terms in e^2, $a' = r - \frac{a^2 e \sin.^2 \theta}{r}$. From the equation $a'^2 = r^2 (1 - 2e' \sin.^2 \theta)$ we also get $b'^2 - a'^2 = b'^2 - r^2 (1 - 2e' \sin.^2 \theta)$; but $b'^2 - a'^2 = 2a'^2 e' = 2a^2 e$; therefore $2a^2 e = b'^2 - r^2 (1 - 2e' \sin.^2 \theta)$, and consequently $b'^2 = r^2 + 2a^2 e \cos.^2 \theta$.

From these values of a' and b'^2 we find, on multiplying and neglecting terms involving the square and higher powers of e, we get $a'b'^2 = r^3 + 2a^2 re \cos.^2 \theta - a^2 re \sin.^2 \theta = r^3 + ra^2 e (2 - 3 \sin.^2 \theta)$. But $b^2 = a^2 (1 + 2e)$, and $ab^2 = a^3 (1 + 2e)$, therefore

$$\frac{ab^2}{a'b'^2}\left(1 + \frac{4}{5}e'\right) = \frac{ab^2}{a'b'^2}\left(1 + \frac{4a^2}{5r^2}e\right)$$

$$= \frac{a^3}{r^3}\left\{1 + 2e - e\frac{3a^2}{5r^2}(2 - 5 \sin.^2 \theta)\right\},$$

and

$$\frac{ab^2}{a'b'^2}\left(1 - \frac{2}{5}e'\right) = \frac{ab^2}{a'b'^2}\left(1 - \frac{2a^2}{5r^2}e\right)$$

$$= \frac{a^3}{r^3}\left\{1 + 2e - e\frac{3a^2}{5r^2}(4 - 5 \sin.^2 \theta)\right\}.$$

Substituting these expressions in the above values of X and Y, writing $r \cos. \theta$ for x', and $r \sin. \theta$ for y', we get

$$\mathrm{X} = \frac{4\pi}{3} k \frac{a^3}{r^2}\left\{1 + 2e - e\frac{3a^2}{5r^2}(2 - 5 \sin.^2 \theta)\right\} \cos. \theta,$$

$$\mathrm{Y} = \frac{4\pi}{3} k \frac{a^2}{r^2}\left\{1 + 2e - e\frac{3a^2}{5r^2}(4 - 5 \sin.^2 \theta)\right\} \sin. \theta.$$

Thus the expression of the force with which a homogeneous spheroid attracts a point placed without it has been found in finite terms. The ingenious process of analysis by which this result, of very great importance in the theory of the figures of the planets, has been obtained, is one of the many discoveries for which mathematical science is indebted to Mr Ivory.

Prop. VII.—To find the measure of the forces with which an oblate spheroid whose ellipticity is small, attracts a particle situated any where on its surface, in the direction parallel to the axis, and in the direction perpendicular to the axis, the density being variable.

In the solution of this problem we suppose the spheroid to be composed of infinitely thin concentric layers, bounded by spheroidal surfaces of different ellipticities, and that the density is uniform for a single layer, but variable from one layer to another.

Let P′Q′ (fig. 15) be the given spheroid, a', b' its polar and equatorial radii, and D the attracted point. Let D be any point within the spheroid P′Q′, and PQD′ be a spheroidal surface at every point of which the density is the same, a, b its polar and equatorial radii, and e its ellipticity. Also let p, q be another spheroidal surface indefinitely near PQ, of which the polar radius C$p = a + da$, the equatorial C$q = b + db$, and the ellipticity $= e + de$. Between the two surfaces PQ and pq the density k may be supposed constant.

In order to find the attraction of the whole spheroid on D, we must first find expressions in terms of a for the forces with which D is attracted by the elementary layer PQpq; the integration of these expressions from $a = 0$ to $a = a'$ will give the attractions of the spheroid.

Conceive for a moment the density of the spheroid CPQ to be uniform and $= k$. The forces X and Y with which this spheroid attracts D are given by the last proposition, and the forces with which Cpq attracts D will be found by substituting $a + da$ for a, and $e + de$ for e in the same expressions for X and Y. Now, as the ellipticity varies from C to P′, e may be regarded as a function of a; its variation is consequently included in the variation of a, and the attractions of the spheroid Cpq hence become

$$\mathrm{X} + \frac{d\mathrm{X}}{da} da, \ \mathrm{Y} + \frac{d\mathrm{Y}}{da} da.$$

The difference between the attractions of the spheroids Cpq and CPQ is the attraction of the layer PQqp, which is therefore $\frac{d\mathrm{X}}{da} da$, and $\frac{d\mathrm{Y}}{da} da$. Hence, if we represent the attractions of the whole heterogeneous spheroid CP′Q′ by X′ and Y′, we shall have

$$\mathrm{X}' = \int \frac{d\mathrm{X}}{da} da, \ \mathrm{Y}' = \int \frac{d\mathrm{Y}}{da} da,$$

which integrals must be taken from $a = 0$ to $a = a'$, the density k, which enters as a factor into X and Y, being regarded as a function of a.

Let us first consider the force X′. By last proposition we have

$$\mathrm{X} = \frac{4\pi}{3} k \frac{a^3}{r^2}\left\{1 + 2e - e\frac{3a^2}{5r^2}(2 - 5 \sin.^2 \theta)\right\} \cos. \theta,$$

Figure of the Earth.

whence

$$\frac{dX}{da}da=\frac{4\pi k}{3\,r^2}\left\{d(\overline{1+2e}.a^3)-\frac{3}{5r^2}(2-5\sin.^2\theta)d(a^5e)\right\}\cos.\theta.$$

Integrating, and regarding k as variable, and a function of a, and going through the same process with respect to Y, we get for the attractions of the spheroid CP′Q′ in the directions respectively parallel and perpendicular to the axis,

$$X'=\frac{4\pi}{3}\left\{\frac{1}{r^2}\int kd(\overline{1+2e}.a^3)-\frac{3(2-5\sin.^2\theta)}{5r^4}\int kd(a^5e)\right\}\cos.\theta,$$

$$Y'=\frac{4\pi}{3}\left\{\frac{1}{r^2}\int kd(\overline{1+2e}.a^3)-\frac{3(4-5\sin.^2\theta)}{5r^4}\int kd(a^5e)\right\}\sin.\theta.$$

Prop. VIII.—To find the measure of the forces with which a heterogeneous layer, included between two level surfaces, attracts a particle situated anywhere within it.

Let D′ (fig. 15) be the given particle situated within the spheroidal layer PQQ′P′, x' and y' the co-ordinates of D′, a = polar semiaxis, and e = eccentricity of the inner surface PQ passing through D′, a' = polar semiaxis of the exterior surface P′Q′, and k = density at the interior surface.

Suppose the interior of the spheroid PQ to be filled with matter of uniform density k, then by Proposition V., the attractions of that spheroid on D′ are

$$X=\frac{4\pi}{3}k\left(1+\frac{4}{5}e\right)x',\ Y=\frac{4\pi}{3}k\left(1-\frac{2}{5}e\right)y';$$

or, changing x' into r cos. θ, and y' into r sin. θ,

$$X=\frac{4\pi}{3}r'k\left(1+\frac{4}{5}e\right)\cos.\theta,\ Y=\frac{4\pi}{3}rk\left(1-\frac{2}{5}e\right)\sin.\theta.$$

Now the attraction of another similar spheroid Cpq, whose polar semiaxis is $a+da$, will be found by substituting $a+da$ for a and $e+de$ for e in the above expressions; and the attraction of the elementary layer PQpq on D will be the difference of these attractions. But

$$\frac{dX}{da}da=\frac{4\pi}{3}\cdot\frac{4}{5}rkde\cos.\theta,$$

$$\frac{dY}{da}da=-\frac{4\pi}{3}\cdot\frac{2}{5}rkde\sin.\theta,$$

e being regarded as a function of a. The integral of these expressions will give the attraction of the layer PQqp on D′; but as this attraction diminishes while a increases, if we take A to represent what $\int kde$ becomes when a becomes a', and denote by X″ and Y″ the attractions of the whole layer PQQ′P′, we shall have

$$X''=\frac{4\pi}{3}\cdot\frac{4}{5}r\left(A-\int kde\right)\cos.\theta,$$

$$Y''=-\frac{4\pi}{3}\cdot\frac{2}{5}r\left(A-\int kde\right)\sin.\theta.$$

Prop. IX.—To find the attraction of a heterogeneous spheroid on a point within it.

Let D′ (fig. 14) be the given point, and CP′Q′ the given spheroid, r cos. θ and r sin. θ the co-ordinates of D′, a', and e', the polar semiaxis and ellipticity of the given spheroid CP′Q′, and a and e those of the spheroidal surface passing through D′ and all the points of equal density.

The whole force urging D′ may be conceived as made up of two parts; that arising from the spheroid CPQ, the surface of which passes through D, and that of the spheroidal shell PQQ′P′. The first of these forces is given by the expressions represented by X′ and Y′ in Prop. VII. and the second by the expressions represented by X″ and Y″ in Prop. VIII. Therefore, if we denote by X‴ and Y‴ the attractions of the whole spheroid on the particle D′, in the direction parallel to the axis, and in the direction perpendicular to the axis, we shall have

$$X'''=X'+X'',\quad Y'''=Y'+Y'';$$

and if the spheroid revolves about its polar axis, Y‴ must be diminished by the amount of the centrifugal force = $\frac{4\pi}{3}\cdot\frac{3\pi}{t^2}r\sin.\theta$; therefore the attractions of the given spheroid on the point D′ are

$$X'''=X'+X'',$$

$$Y'''=Y'+Y''-\frac{4\pi}{3}\cdot\frac{3\pi}{t^2}r\sin.\theta.$$

Prop. X.—To find the ratio of the ellipticity to the density of any level surface, when the component of all the forces urging any point on the surface is perpendicular to the surface.

The forces urging the particle D′ (fig. 14) being X‴ and Y‴, in order that their resultant may be perpendicular to the surface, we must have

$$X''':Y'''=ME:ED\ \text{(fig. 10)}.$$

But ME (the subnormal) $=\frac{b^2}{a^2}x'=(1+2e)x'$, and ED $=y'$; therefore X‴ : Y‴ $=(1+2e)x':y'$, whence, substituting r cos. θ for x' and r sin. θ for y', $\frac{X'''}{\cos.\theta}-\frac{Y'''}{\sin.\theta}(1+2e)=0.$

Now, if we substitute for X‴ in this equation the values of X′ and X″ given by Propositions VII. and VIII., and for Y‴ the values of Y′ and Y″ multiplied by $(1+2e)$, and neglect terms involving e^2, we shall find, on changing the signs and having regard to the centrifugal force,

$$\frac{2e}{r^2}\int kd(\overline{1+2e}.a^3)-\frac{6}{5r^4}\int kd(a^5e)-\frac{6}{5}r\left(A-\int kde\right)-\frac{3\pi r}{t^2}=0.$$

Dividing by $2r$, and substituting a for r (which may be done without sensible error, because all the terms of the equation are small, and because r^2 differs from a^2 only by a quantity depending on the ellipticity e), we shall find

$$\frac{e}{a^3}\int kd(\overline{1+2e}.a^3)-\frac{3}{5a^5}\int kd(a^5e)-\frac{3}{5}\left(A-\int kde\right)-\frac{3\pi}{2t^2}=0.$$

From this we infer that if k and e have the relation to each other indicated by this equation, and that e is very small from $a=0$ to $a=a'$, each of the level surfaces will be intersected at every point by the resultant of the attractive forces under an angle which will differ from a right angle only by an infinitesimal of the second order, supposing the centrifugal force to be very small in comparison of gravity. Hence, neglecting quantities of the second order, the elliptical spheroid (supposing the equation possible) is a figure of equilibrium.

In order to discover whether the equation which has now been obtained is possible, it must be differentiated twice in order to eliminate $\int kd(a^5e)$ and $\int kde$, both of which contain the ellipticity e. Observing that as the first term is multiplied by e, we may suppose, without sensible error, $\frac{e}{a^3}\int kd(\overline{1+2e}.a^3)=\frac{e}{a^3}\int kd(a^3)=\frac{3e}{a^3}\int ka^2da$, and the first differentiation gives, on multiplying by a^6,

$$\frac{de}{da}a^3\int ka^2da-3a^2e\int ka^2da+\int kd(a^5e)=0.$$

Differentiating again, and considering da as constant, we shall find, after reduction,

$$\frac{d^2e}{da^2}+\frac{2ka^2}{\int ka^2da}\cdot\frac{de}{da}+\left(\frac{2ka}{\int ka^2da}-\frac{6}{a^2}\right)e=0.$$

This is the equation given by Clairaut (*Figure de la Terre*, p. 276). It can be integrated by the usual methods when k is expressed in terms of a; consequently the equilibrium is always possible if the density is a function of the distance from the centre. The integration being performed, an equation will result between the densities and ellipticities of the different spheroidal layers, by means of which, when one of these elements is supposed to be given, the other can be determined.

Prop. XI.—To find the whole force urging a particle situated at any point on the surface of a heterogeneous spheroid revolving about its shorter axis.

By Prop. VII. the force urging the particle in the direction of the axis is X′, and in the direction perpendicular to the axis Y′; but in consequence of the centrifugal force, the latter becomes $Y' - \varphi$, therefore the whole force urging D in the direction of the normal

$$=\sqrt{X'^2+(Y'-\varphi)^2}.$$

Neglecting the terms which involve e^2 and $e\varphi$ (φ being small as well as e), and putting $\int kd\,(\overline{1+2e\cdot a^3}) = M$, and $\int kd\,(a^5 e) = N$, and substituting $\frac{4\pi^2}{t^2} r \sin.\theta$ for φ, we get

$$X'^2 = \left(\frac{4\pi}{3r^2}\right)^2 \left\{ M^2 \cos.^2\theta - \frac{6(2-5\sin.^2\theta)}{5r^2} M N \cos.^2\theta \right\},$$

$$(Y'-\varphi)^2 = \left(\frac{4\pi}{3r^2}\right)^2 \left\{ M^2 \sin.^2\theta - \frac{6(4-5\sin.^2\theta)}{5r^2} MN \sin.^2\theta \right.$$
$$\left. \frac{6M\pi r^3 \sin.^2\theta}{t^2} \right\};$$

whence, putting $X^2 + (Y-\varphi)^2 = U^2$, there results

$$U^2 = \left(\frac{4\pi}{3r^2}\right)^2 \left\{ M^2 - \frac{6(2-3\sin.^2\theta)}{5r^2} MN \right.$$
$$\left. - \frac{6M\pi r^3 \sin.^2\theta}{t^2} \right\},$$

and extracting the square root,

$$U = \frac{4\pi}{3} \left\{ \frac{M}{r^2} - \frac{3(2-3\sin.^2\theta)}{5r^4} N - \frac{3\pi r \sin.^2\theta}{t^2} \right\}.$$

But the equation of the ellipse gives

$$r^2 \cos.^2\theta + \frac{r^2 \sin.^2\theta}{1+2e} = a^2;$$

whence we deduce $r^2 = a^2(1+2e\sin.^2\theta)$; therefore, substituting and dividing, and neglecting terms in Ne and $e\varphi$,

$$U = \frac{4\pi}{3} \left\{ \frac{M}{a^2}(I - 2e\sin.^2\theta) - \frac{3}{5}\cdot\frac{(2-3)\sin.^2\theta}{a^4} N \right.$$
$$\left. - \frac{3\pi^2 a \sin.^2\theta}{t^2} \right\}$$

Let the centrifugal force at the equator $= m \times$ gravity; then, if m is a very small fraction (as in the case of the earth, where $m = \frac{1}{289}$), terms involving the product me may be neglected, and the last equation, multiplied by m, will become

$$mU = \frac{4\pi}{3}\cdot\frac{M}{a^2} m;$$

but the centrifugal force at the equator $= \frac{4\pi^2}{t^2} a(1+e)$, which does not differ sensibly from $\frac{4\pi^2}{t^2} a$; therefore $\frac{4\pi^2}{t^2} a = \frac{4\pi}{3} \frac{M}{a^2} m$, or $\frac{3\pi}{t^2} = \frac{Mm}{a^3}$. Now, at the surface the equation of equilibrium in Prop. X. becomes

$$\frac{e}{a^3} M - \frac{3}{5a^5} N - \frac{3\pi}{2t^2} = 0,$$

therefore

$$\frac{e}{a^3} M - \frac{3}{5a^5} N - \frac{Mm}{2a^3} = 0,$$

whence

$$\frac{3N}{5a^4} = \frac{M}{a^2}\left(e - \frac{m}{2}\right).$$

Substituting these values of $\frac{3\pi}{t^2}$ and $\frac{3N}{5a^4}$ in the above value of U, we get, after reduction,

$$U = \frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1 - 2e + m - \left(\frac{5}{2}m - e\right)\sin.^2\theta\right\}.$$

At the equator $\sin.\theta = 1$, and this equation becomes

$$Q = \frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1 - e - \frac{3}{2}m\right\};$$

and at the pole, where $\sin.\theta = 0$, it gives

$$P = \frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1 - 2e + m\right\};$$

consequently the difference between the force of gravity at the pole and that of gravitation at the equator is $\frac{4\pi}{3}\cdot\frac{M}{a^2}\left(\frac{5m}{2} - e\right)$. Dividing this by the polar gravity P, we get for the quotient $\frac{5m}{2} - e$, which, therefore, expresses the ratio of the excess of the polar gravity above the gravitation at the equator to the gravity at the pole. Let this ratio $= n$, we have then

$$n = \frac{5}{2}m - e;$$

a very remarkable relation between the gravity and ellipticity, which was discovered by Clairaut, and is generally called *Clairaut's theorem.*

If we substitute $1 - \cos.^2\theta$ for $\sin.^2\theta$ in the equation

$$U = \frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1 - 2e + m - \left(\frac{5}{2}m - e\right)\sin.^2\theta\right\},$$

we get

$$U = \frac{4\pi}{3}\cdot\frac{M}{a^2}\left\{1 - e - \frac{3}{2}m + \left(\frac{5}{2}m - e\right)\cos.^2\theta\right\};$$

or, neglecting quantities of the order me,

$$U = \frac{4\pi}{3}\cdot\frac{M}{a^2}\left(1 - e - \frac{3}{2}m\right)\left\{1 + \left(\frac{5}{2}m - e\right)\cos.^2\theta\right\};$$

whence we have $U = Q(1 + n\cos.^2\theta)$. Now in this equation the angle θ may be taken for the complement of the latitude, from which indeed it differs only by a quantity of the second order, and the equation then becomes $U = Q(1 + n\sin.^2 l)$; whence we infer that, on going from the equator towards the pole, the increase of gravity is proportional to the square of the sine of the latitude.

Let p be the length of the seconds pendulum at the equator, p' its length at any latitude l, and U the intensity of the gravitating force at the same latitude l. When the time of oscillation is constant, the length of the pendulum is directly proportional to the intensity of gravity; therefore $p' : p = U : Q$, and consequently

$$\frac{p'-p}{p} = \frac{U-Q}{Q}.\quad \text{But } U = Q(1 + n\sin.^2 l),$$

therefore, $\frac{p'-p}{p} = n\sin.^2 l = \left(\frac{5m}{2} - e\right)\sin.^2 l.$

At the pole $\sin.l = 1$, and $\frac{p'-p}{p} = \frac{5m}{2} - e$; therefore, since $e = \frac{b-a}{a}$, $\frac{p'-p}{p} + \frac{b-a}{a} = \frac{5m}{2}$.

Now it has been shown that in the case of a homogeneous spheroid the ellipticity is $\frac{5\,m}{4}$; hence we have this theorem:

In the case of a heterogeneous spheroid, the excess of the length of the pendulum at the pole above its length at the equator divided by its length at the equator, and the excess of the axis of the equator above the polar axis divided by the polar axis, form two fractions, of which the sum is constant, and equal to twice the ellipticity the spheroid would have if homogeneous.

SECTION IV.

ON THE FIGURE OF THE EARTH AS DETERMINED BY OBSERVATIONS OF THE PENDULUM.

As the various methods of determining the length of a pendulum which makes a given number of vibrations in a mean solar day, and the corrections that are required to reduce the observations to the same circumstances in respect of altitude, temperature, barometric pressure, &c. form the subject of a separate article, we shall here limit ourselves to a brief abstract of the results of some of the latest and best observations.

The ellipticity of the earth is deduced from the observed number of vibrations made by an invariable pendulum of a given length at different latitudes, by means of the theorem of Clairaut. Let $N =$ the number of oscillations made by a pendulum at the equator in a mean solar day, $N' =$ the number of oscillations made by the same pendulum at the latitude l; then Q representing, as before, the gravitation at the equator, and U the gravitation at latitude l, we have, by the last proposition in the preceding section,

$$U = Q\,(1 + n \sin.^2 l).$$

But by the property of the invariable pendulum, the square of the number of vibrations is directly proportioned to the force of gravitation; therefore $U : Q = N'^2 : N^2$, whence $N'^2 = N^2\,(1 + n \sin.^2 l)$.

In this equation $n = \frac{5}{2}\,m - e = \frac{5}{2 \times 289} - e$; therefore, as N'^2 is given by observation at any station, we can, by combining the results at two different latitudes, determine N and n, and consequently e. The pendulum gives no information respecting the magnitude of the earth.

Instead of N and N′, we might substitute in the above equation the lengths of the seconds pendulum at the equator, and the latitude l (the length of the seconds pendulum being also directly proportional to the intensity of gravity); but as the invariable pendulum is now almost universally employed for the measurement of the variations of gravity, the formula under the above form is more immediately applicable to the results of observation. The absolute length of the pendulum (which is not very easily determined) has no concern with the present question.

For the purpose of exhibiting the variations of gravity, we shall confine our attention to the results that have been found from observations with the invariable pendulum. The results given by pendulums of a different kind are probably not less exact, but they are not directly comparable, on account of the great uncertainty that remains respecting the correction that ought to be applied for the buoyancy of the atmosphere.

In the seventh volume of the *Memoirs of the Royal Astronomical Society*, Mr Baily has given the results of fourteen different sets of observations with invariable pendulums. They are as follows:

1. The observations of Captain Kater at different stations in Great Britain. These are detailed in the *Philosophical Transactions* for the year 1819.

2. Those of Mr Goldingham at London and Madras, and of Mr Lawrence and Mr Robinson with the same pendulum at the small island of Pulo Guansah Lout, on the western coast of Sumatra, and almost immediately under the equator. (*Phil. Trans.* 1822.)

3. Those of Captain Hall at the Galapagos Islands, San Blas, Rio Janeiro, and London. (*Phil. Trans.* 1823.)

4. Those of Sir Thomas Brisbane at London and Paramatta. (*Phil. Trans.* 1823.)

5. Those of Captain Sabine in various parts of the Atlantic Ocean and the North Sea, in the years 1822-4. (Sabine's *Account of Experiments*, &c. 1825.)

6. Those of Captain Foster at Greenwich, London, and Port Bowen. (*Phil. Trans.* 1826.)

7. Those of Mr Fallows at the Cape of Good Hope. The same pendulum was swung in London previous to its departure.

8, 9, 10. Those of Captain Sabine for the purpose of determining the difference in the number of oscillations at London and Paris (*Phil. Trans.* 1828), London and Greenwich (*Phil. Trans.* 1829), and at Greenwich, London, and Altona (*Ibid.* 1829 and 1830).

11. Those of Captain Freycinet, who commanded an expedition fitted out by the French government in 1817, for the purpose of making scientific observations in a voyage round the world. The stations at which the experiments were made were the island of Rawak (near the coast of Guinea), Guam (one of the Ladrones), the Isle of France, Mowi (one of the Sandwich Islands), Rio Janeiro, Port Jackson, Cape of Good Hope, Paris, and the Falkland Islands. (*Voyage autour du Monde, par M. Freycinet.*)

12. Those of Captain Duperrey, who commanded another French expedition. The stations were, island of Ascension, Isle of France, Port Jackson, Toulon, Paris, and the Falkland Islands. (*Connoissance des Tems* for 1830.)

13. Those of Captain Leutke, a Russian officer, under whose orders a ship of war was dispatched to the South Seas, for the purpose, among other things, of swinging the pendulum at various places. The stations at which experiments were made were Ualan (one of the Caroline Isles), Guam, St Helena, Bonin Island (off the south-east coast of Japan), Valparaiso, Greenwich, Petropaulouski, Sitka (off the north-west coast of America), and Petersburg. (Mr Baily's Report in the *Memoirs of the Royal Astronomical Society*, vol. vii.)

14. Those of Captain Foster, in his last voyage, which commenced in 1828, and which form perhaps the most valuable series of the whole. The observations were made at fourteen different stations, principally in the southern hemisphere, from the equator to the latitude of 63°. Captain Foster carried out with him four pendulums, two of brass, one of iron, and one of copper, and at seven of the stations all four were swung. The details are published at full length in the volume of the *Astronomical Society's Memoirs* to which we have already referred, with an excellent Report by Mr Baily.

The results of all these observations are contained in the following table, in which the observed number of vibrations at each station is corrected, for any deviation from the standard temperature of 62°, or from the true correction for the buoyancy of the atmosphere, and afterwards reduced to a comparison with Captain Foster's mean pendulum, assumed as making 86,400 vibrations in a mean solar day at London.

No.	Station.	Latitude.	Vibrations. Observed.	Vibrations. Computed.	Difference.	Observer.
1	Rawak	0° 1′ 34″ S.	86261·46	86264·86	— 3·40	Freycinet.
2	Pulo Guansah Lout	0 1 49 N.	86266·64	86264·86	+ 1·78	Goldingham.
3	St Thomas	0 24 41 —	86268·84	86264·87	+ 3·97	Sabine.
4	Galapagos	0 32 19 —	86264·56	86264·88	— 0·32	Hall.
5	Para	1 27 0 S.	86260·61	86265·00	— 4·39	Foster.
6	Maranham	2 31 35 —	86258·74	86265·30	— 6·56	Foster.
7	Ditto	2 31 43 —	86259·19	86265·30	— 6·11	Sabine.
8	Fernando de Noronha	3 49 59 —	86271·20	86265·86	+ 5·34	Foster.
9	Ualan	5 21 16 N.	86275·44	86266·78	+ 8·66	Leutke.
10	Ascension	7 55 23 S.	86272·26	86269·06	+ 3·20	Foster.
11	Ditto	7 55 48 —	86272·06	86269·08	+ 2·98	Duperrey.
12	Ditto	7 55 48 —	86272·56	86269·08	+ 3·48	Sabine.
13	Sierra Leone	8 29 28 N.	86267·54	86269·70	— 2·16	Sabine.
14	Porto Bello	9 32 30 —	86272·01	86270·96	+ 1·05	Foster.
15	Trinidad	10 38 55 —	86267·24	86272·42	— 5·18	Foster.
16	Ditto	10 38 56 —	86266·78	86272·42	— 5·64	Sabine.
17	Bahia	12 59 21 S.	86272·38	86276·07	— 3·69	Sabine.
18	Madras	13 4 9 N.	86272·36	86276·19	— 3·83	Goldingham.
19	Guam	13 26 21 —	86280·64	86276·84	+ 3·80	Leutke.
20	Ditto	13 27 51 —	86282·98	86276·90	+ 6·08	Freycinet.
21	St Helena	15 54 59 S.	86288·29	86281·54	+ 6·75	Leutke.
22	Ditto	15 56 7 —	86288·29	86281·54	+ 6·75	Foster.
23	Jamaica	17 56 7 N.	86284·66	86285·90	— 1·24	Sabine.
24	Isle of France	20 9 23 S.	86297·60	86291·20	+ 6·40	Duperrey.
25	Ditto	20 9 56 —	86298·08	86291·23	+ 6·85	Freycinet.
26	Mowi	20 52 7 N.	86297·52	86293·00	+ 4·52	Freycinet.
27	St Blas	21 32 24 —	86288·80	86294·77	— 5·97	Hall.
28	Rio Janeiro	22 55 13 S.	86293·48	86298·52	— 5·04	Freycinet.
29	Ditto	22 55 22 —	86294·90	86298·52	— 3·62	Hall.
30	Bonin Island	27 4 12 N.	86322·06	86310·81	+ 11·25	Leutke.
31	Valparaiso	33 2 30 S.	86328·16	86330·82	— 2·66	Leutke.
32	Paramatta	33 48 43 —	86331·48	86333·55	— 2·07	Brisbane.
33	Port Jackson	33 51 34 —	86334·06	86333·68	+ 0·38	Freycinet.
34	Ditto	33 51 40 —	86332·94	86333·68	— 0·74	Duperrey.
35	Cape of Good Hope	33 54 37 —	86331·33	86333·90	— 2·57	Foster.
36	Ditto	33 55 15 —	86331·58	86333·95	— 2·37	Freycinet.
37	Ditto	33 55 56 —	86332·56	86333·98	— 1·42	Fallows.
38	Monte Video	34 54 26 —	86334·36	86337·48	— 3·12	Foster.
39	New York	40 42 43 N.	86358·06	86359·22	— 1·16	Sabine.
40	Toulon	43 7 20 —	86367·16	86368·48	— 1·32	Duperrey.
41	Paris	48 50 14 —	86388·01	86390·54	— 2·53	Freycinet.
42	Ditto	48 50 14 —	86388·30	86390·54	— 2·24	Sabine.
43	Ditto	48 50 14 —	86388·56	89390·54	— 1·98	Duperrey.
44	Shanklin Farm	50 37 24 —	86396·40	86397·32	— 0·92	Kater.
45	Greenwich	51 28 40 —	86398·90	86400·58	— 1·68	Foster.
46	Ditto	51 28 40 —	86399·24	86400·58	— 1·34	Leutke.
47	Ditto	51 28 40 —	86399·46	86400·58	— 1·12	Foster.
48	Ditto	51 28 40 —	86400·67	86400·58	+ 0·09	Sabine.
49	Ditto	51 28 40 —	86400·72	86400·58	+ 0·14	Sabine.
50	London	51 31 8 —	86399·76	86400·74	— 0·98	Fallows.
51	Ditto	51 31 8 —	86399·90	86400·74	— 0·84	Foster.
52	Ditto	51 31 8 —	86399·72	86400·74	— 1·03	Sabine.
53	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Kater.
54	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Goldingham.
55	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Hall.
56	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Brisbane.
57	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Sabine.
58	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Sabine.
59	Ditto	51 31 8 —	86400·00	86400·74	— 0·74	Sabine.
60	Ditto	51 31 17 —	86400·00	86400·75	— 0·75	Foster.
61	Falkland Island	51 31 44 S.	86399·84	86400·78	— 0·94	Duperrey.
62	Ditto	51 35 18 —	86396·74	86400·99	— 4·25	Freycinet.
63	Arbury Hill	52 12 55 N.	86403·68	86403·35	+ 0·33	Kater.
64	Petropaulouski	53 0 53 —	86408·90	86406·34	+ 2·56	Leutke.
65	Clifton	53 27 43 —	86407·48	86407·99	— 0·51	Kater.
66	Altona	53 32 45 —	86408·98	86408·28	+ 0·70	Sabine.
67	Staten Island	54 46 23 S.	86415·22	86412·80	+ 2·42	Foster.
68	Cape Horn	55 51 20 —	86417·98	86416·72	+ 1·26	Foster.
69	Leith Fort	55 58 41 N.	86418·02	86417·16	+ 0·86	Kater.
70	Sitka	57 2 58 —	86420·54	86420·96	— 0·42	Leutke.
71	Portsoy	57 40 59 —	86424·70	86423·21	+ 1·49	Kater.
72	Petersburg	59 56 31 —	86432·20	86430·94	+ 1·26	Leutke.
73	Unst	60 45 28 —	86435·40	86433·64	+ 1·76	Kater.
74	South Shetland	62 56 11 S.	86444·52	86440·65	+ 3·87	Foster.
75	Drontheim	63 25 54 N.	86438·64	86442·20	— 3·56	Sabine.
76	Hammerfest	70 40 5 —	86461·14	86462·23	— 1·09	Sabine.
77	Fort Bowen	73 13 39 —	86470·48	86468·06	+ 2·42	Foster.
78	Greenland	74 32 19 —	86470·72	86470·75	— 0·03	Sabine.
79	Spitzbergen	79 49 58 —	86483·28	86479·58	+ 3·70	Sabine.

Taking the mean results of the observed vibrations given in col. 4 of the above table, and forming with each of them the equation of condition $N'^2 = N^2 (1 + n \sin.^2 l)$, seventy-nine equations are formed, from which, on deducing the values of N^2 and n by the method of least squares, Mr Baily obtained the following results:

$$N^2 = 7441625711$$
$$n = \cdot 00514491$$
$$e = \frac{1}{285 \cdot 26}.$$

By means of these values of N^2 and n, the number of vibrations made by a pendulum which beats seconds at London, at any latitude l, supposing the earth to be a regular spheroid, is given by the formula

$$N' = 86246 \cdot 8 (1 + \cdot 00514491 \sin.^2 l)^{\frac{1}{2}};$$

and from this the results given in col. 5 of the table have been computed.

Although the differences between the observed and computed vibrations are in some instances considerable, the observations are on the whole well represented by supposing the ellipticity $= \frac{1}{285 \cdot 26}$. To be satisfied of this, it will be sufficient to remark, that as the differences in the table present twenty-four alternations of sign, the curve which represents all the observations intersects the meridian having that ellipticity no less than twenty-four times along an arc of 152° (from Spitzbergen to South Shetland), or, on an average, once for every 6¼ degrees; and (with the exception of the island of Bonin) the deviations on the opposite sides are nearly equal.

If, instead of seeking an ellipticity by the *fusion* (if we may so speak) and agglomeration of all the observations by the method of least squares, we consider the results of the different voyagers separately, we shall find marked differences among them. Taken by themselves, Captain Sabine's observations give $e = \frac{1}{288 \cdot 4}$; Captain Foster's, $e = \frac{1}{289 \cdot 5}$; Duperrey's, $e = \frac{1}{266 \cdot 4}$; Freycinet's, $e = \frac{1}{267 \cdot 6}$; and Leutke's, $e = \frac{1}{267 \cdot 7}$. The singular agreement of the results of the foreign voyagers with each other, and their difference from those of Captains Sabine and Foster, which also agree well with each other, have not been satisfactorily explained.

In one of the numbers of the *Annales des Sciences d'Observation* (tome i. No. 3), M. Saigey has computed the ellipticity from fifty-one different observations, combined by the method of least squares. Captain Foster's observations are of course not included in the table; but it contains those of Biot, made with a variable pendulum at different stations along the French and British arcs of meridian, and more recently in Italy and the Lipari Islands. The result gives $e = \frac{1}{286 \cdot 5}$.

The differences between the observed and computed values are, in many instances at least, too great to be ascribed entirely to errors of observation. They must, therefore, be occasioned by real differences in the intensity of gravity, arising either from variations in the density of the materials which compose the exterior crust of the earth, or from local deviations of its form from that of the regular spheroid. On attending to the preceding table, it will be perceived that the differences are generally in excess where the station is on small islands, and especially if situated at a great distance from the main land. From this it may be inferred, that such islands are composed of denser materials than the general crust of the earth; but it is not improbable that part of this effect may be occasioned by a difference of the level of the surface of the ocean. On the shores of elevated continents, the direction of gravity is altered by the action of the high land; and the surface of the water, which is perpendicular to gravity, deviates from the regular curvature, and becomes elevated above the general level of the ocean. Hence the apparent elevation is less than the real elevation of the station, and the observed intensity of gravity is consequently less than it was calculated to be. How far the disturbing influence of this cause may affect the results, will be better understood when we shall be furnished with numerous pendulum observations, made in the interior of the large continents, and at a great distance from the sea.

All the pendulum experiments agree in giving a greater ellipticity to the earth than that which is deduced from the comparison of arcs of meridian. To what cause this discrepancy is to be assigned is by no means apparent. The geological character of the country in the immediate neighbourhood of the station probably exerts a considerable influence in accelerating or retarding the pendulum; but the experiments have now been made at so many points, that we might expect to find the effects of local irregularities almost entirely eliminated, and a much nearer agreement between the results of the two methods of investigation than actually exists. We can, however, have no difficulty in giving the preference to the results of the geodetic measures.

It was mentioned in the first section of this article that the ellipticity of the earth may be deduced from certain inequalities in the motions of the moon, to which it gives rise; but this part of the subject belongs to the theory of the lunar perturbations. The ellipticity so deduced is about $\frac{1}{306}$, which agrees well with that given by the meridional arcs; and the result has the advantage of being entirely independent of local disturbance.

One conclusion cannot fail to be drawn from the results of this enquiry. However irregular the surface of the earth may be in its details, its general form agrees so nearly with the figure of hydrostatic equilibrium, that the agreement cannot be regarded as fortuitous or accidental. The regular increase of gravity from the equator to the poles, indicated by the pendulum experiments, also proves that it is symmetrically constituted, or that the materials in its interior are disposed about the centre of gravity in regular elliptical strata, and arranged according to the order of density. The earth must therefore have taken its present form while its particles were at liberty to arrange themselves in obedience to the forces arising from their mutual attractions and from the rotation; in other words, it must have existed at some period of time in a state of fluidity. This inference, which so many geological facts tend to confirm, may be extended to all the other planets. (s.)

FILAMENT, in *Anatomy* and *Natural History*, a term used in the same sense with fibre, and signifying those fine threads of which the flesh, nerves, skin, plants, roots, &c. are composed.

Vegetable FILAMENTS form a substance of great use in the arts and manufactures; furnishing thread, cloth, cordage, and the like. For these purposes the filamentous parts of the *Cannabis* and *Linum*, or hemp and flax, are commonly used amongst us. But different vegetables have been employed in different countries for the same uses. Putrefaction destroys the pulpy or fleshy matter, and leaves the tough filaments entire. By putrefying the leaf of a plant in water, we obtain the fine flexible fibres which constitute the basis of the ribs and minute veins, and form as it were a skeleton of the leaf. The Sieur de Flacourt, in his history of Madagascar, relates that different kinds of cloth are prepared in that island from the filaments of the bark of certain trees boiled in a strong lye; that some of these cloths are very fine, and approach to the softness of silk, but in durability fall short of cotton; that others are coarser and stronger, and last thrice as long as cotton; and that of these the sails and cordage of his vessel were made.

FILANDERS, in falconry, a disease in hawks, and some other birds, consisting of filaments or strings of blood coagulated; and occasioned by a violent rupture of a vein, by which the blood extravasated hardens into these figures, and incommodes the reins, hips, and other parts.

FILANDERS are also worms as small as thread, and about an inch long, which lie wrapt up in a thin skin or net, near the reins of a hawk, apart from either gut or gorge.

FILANGIERI, GAETAN, celebrated for his valuable works on political economy and legislation, was born at Naples on the 18th of August 1752. He was the third son of Cesar prince of Araniello, by Marianne Montalto, daughter of the Duke of Fragnito. His family was ancient, and rose to distinction at the first establishment of the Neapolitan monarchy. Angerio, its founder, was the son of one of those brave Normans who landed in Italy about the beginning of the eleventh century, and accompanying Count Roger in all his military expeditions, received from him ample domains as the reward of his exploits. His descendants were allowed to take the honourable title of *Filii Angerii*, and hence the name Filangieri. Gaetan from his infancy was destined for the profession of arms; when he was seven years of age he was enrolled in one of the royal regiments, and he commenced actual service at the age of fourteen. His education was at first neglected, from a misconception of his character, which was supposed to be averse to all literary or speculative pursuits. The injudicious methods adopted at that time in the teaching of Latin had, it seems, disgusted him, and alienated his mind from the study of this language; and hence an impression had been hastily taken up of his general unfitness for all literary exercises. A lucky accident, however, not only removed this apprehension, but showed that his former impatience of the modes of tuition then in use arose from the clearness and vigour of his judgment. It happened that his brother's preceptor had one day mistaken the solution of some geometrical problem. Gaetan immediately perceived the source of this error, which he demonstrated to the master. This incident, apparently trivial, determined his future destiny. Encouraged by his success, he quitted the military service, and determined to follow his natural taste for science and philosophy. So diligent was he in repairing the defects of his education, that at twenty years of age he had acquired a knowledge of Greek and Latin, of ancient and modern history, of the great principles both of civil and of public law, and was besides well initiated in mathematical science. Although his genius inclined him solely to the study of legislation and policy, he sacrificed his views to the wishes of his friends, and entered on the profession of the law, which was then the certain road both to honour and fortune. His eloquence and his extensive knowledge soon obtained him success; and, about this period, a circumstance happened which greatly conduced to his celebrity. Enormous abuses prevailed in the administration of justice at Naples, arising from the uncertainty of the law, which occasioned constant misconceptions, and almost always led to arbitrary judgments. By a wise ordinance of the king, passed in the year 1774, at the suggestion of the minister Tanucci, those abuses were reformed; the law was restored to its proper authority; its judgments were freed from the control of precedents; and the judges were ordained in every case to publish the grounds of their decisions. Although this reform was generally applauded, it excited the murmurs of the bar. Filangieri now became the advocate of the court, and published a defence of the royal decree, founded upon the most enlarged views of equity and reason. The extensive knowledge and matured judgment displayed in this performance attracted the attention of the ministers, and Filangieri was encouraged to pursue the course in which he had already acquired so much distinction. Through the influence of his uncle, the Archbishop of Palermo, he was in 1777 placed in an honourable office at court; and almost at the same time he was named officer of the royal corps of marine volunteers, who were more particularly attached to the king's person. But his abode at court neither broke in upon his regular habits of life, nor interrupted the course of his studies; nor did he allow it to interfere with the composition of the great work on legislation and government in which he was engaged, and to which for several years past he had devoted all his inquiries. About the commencement of the eighteenth century a great school of philosophy had been formed at Naples, in which the principles of the civil law, of the law of nations, and of legislation, were established on the solid and comprehensive basis of general utility. From this school numerous works of celebrity have proceeded; amongst others, the great work of Beccaria, which, though confined to one branch of legislation, contains principles which are of universal application. There was still wanting, however, a general treatise on legislation, for the purpose of examining the science in all its relations, and of laying down some common and universal principles of equity and expediency as its only true basis; and it was to this important undertaking that Filangieri's philosophical mind was now directed. His subject he proposed to divide into seven books. The first, in which he demonstrates the general rules of legislation, and the second, which treats on political laws, and on those laws also which are connected with the general structure of society, appeared at Naples in 1780; and such was its popularity, that not only in Italy, but throughout Europe at large, the author was ranked among the most celebrated writers on public law. According to his theory, the goodness of laws is either absolute or relative. It is absolute when they are agreeable to those great and universal principles of equity and expediency which are obligatory on man under every diversity of country, climate, government, or manners; it is relative, according as the laws agree with the nature of the government, with the genius and character of the people, with the climate, with the fertility or sterility of the soil, with the physical circumstances of the country, with the religion of the inhabitants, and with the degree of civilization to which they have advanced. In his second book, which treats of political laws, and of those laws also which are connected with the general economy of society, he examines two points; namely, the state of population and of wealth. With respect to the first point, the great question which he considers is, whether Europe is as populous as it might be? This question he resolves in the

Filangieri.

negative, and he proceeds to explain the causes of this deficient population. According to his hypothesis, the state of agriculture affords in every country the surest evidence as to the state of the population; but the backwardness of agriculture in most parts of Europe sufficiently indicates that the population is deficient; therefore he infers the defective state of European legislation on these two capital points. The great obstacles to the improvement of agriculture, and, consequently, to the increase of population, he considers to be, 1*st*, the small number of proprietors, and the great number of non-proprictors; 2*dly*, too many large, and too few small properties; 3*dly*, the exorbitant and inalienable possessions of the church in several states; 4*thly*, the excess of the public imposts, and the violent modes of levying them; 5*thly*, to these he adds other causes of less importance, such as the state of most of the regular troops of the European states; also public corruption, and the dissoluteness of private morals. The progress of agriculture, the great source of wealth as well as of population, may also be obstructed by a bad political administration, by bad laws, or by those causes which occasion a great influx of inhabitants to the respective capitals of the different states. It belongs to a pure system of legislation to remove some of those obstacles, and to counterbalance such others as are inevitable, by suitable encouragements. Having discussed those momentous questions, he next enters into a comprehensive survey of the other sources of riches, namely, arts, manufactures, and commerce, and points out how these may be obstructed by a faulty legislation, and, at the same time, the means by which such obstructious may be removed. In order fully to comprehend the merits of these performances, we must consider that all the faults which the author reprehends were committed by his own government; a circumstance which imposed on him the delicate task of stating obnoxious truths with freedom and boldness, and, at the same time, without giving unnecessary offence. So well, however, did he appreciate the views of those whom it was his wish to enlighten, that he was immediately promoted by the king to a commandery in the royal order of Constantine. In 1783 he married a Hungarian lady of noble birth, who was entrusted with the education of the second daughter of the king, and who to outward attractions united the gift of a sound judgment and an agreeable disposition. That he might the more freely enjoy domestic happiness, and, at the same time, have leisure for the composition of his work, on which he became every day more intent, he resigned, with the consent of the king, all his military employments and his office at court, and retired to a country-seat about twenty miles from Naples. In the same year he published his third book, relating entirely to the principles of criminal jurisprudence. In these discussions he maintains the same tone of decision and independence as before. Abuses are freely pointed out, and the defects of the penal code, and the forms of criminal procedure, are fairly exposed. In thus pointing out those defects in the domestic administration of his government, Filangieri excited the hatred of an interested and powerful class; and a proposition which he made in his third book, for the reformation of abuses in the Roman Catholic church, drew down upon his work the censure of some of the ecclesiastical tribunals. In 1785, however, he published the fifth, sixth, and seventh volumes of his work, which comprehended his fourth book. These were devoted to the consideration of education, morals, and public instruction; and though on these important points we may be occasionally disposed to question his views, we must nevertheless admire his mild and philosophical spirit still opposed to every excess, his extensive knowledge, and his happy talent of arranging and combining it for the illustration of his argument; his animated, flowing, and perspicuous style; and, above all, that rectitude and philanthropy which are diffused over all his reasonings. His fifth book, which treated of the laws relative to religion, was soon afterwards published. But his health was now considerably impaired, owing to an excess of application, so that the remainder of his work advanced but slowly; and other interruptions soon followed. In the year 1787 he was called by the new king, Ferdinand IV., to the supreme council of finance. He returned to Naples, and from that time was wholly engrossed with the important business of this office. His health, already injured, was soon completely broken by severe and active application; and several domestic misfortunes operating upon a mind of deep sensibility, at last threw him into a state of melancholy. He finally retired from all business into the country, where he soon afterwards became seriously ill, and on the 21st of July 1788 he expired. Before his death he had finished the eighth volume of his work, containing the first part of the fifth book, in which he treats of the different systems of religion that preceded Christianity. Of the second part of the same book he had only made a rude sketch, in which were noted down the principal subjects of discussion; namely, the advantages of Christianity and the dangers of superstition; the inconveniences of mixing spiritual with temporal concerns; the excessive riches of the clergy, and the immense increase of their power. He was also to examine the foundation of ecclesiastical rights, and to present, in a new system of legislation, a remedy for the abuses which he pointed out. A chapter on toleration would have terminated this book. In his sixth book he proposed to treat of the laws relative to property; and in his seventh and last, of the nature of the paternal power and the government of families. He had also other important works in contemplation when his course was terminated by death. This eminent person, besides some of the rarest gifts of genius, was endowed by nature with the additional advantage of a most imposing presence. His manners were eminently graceful and dignified. His countenance bore the traces of habitual reflection, and of deep sensibility, mingled with an expression of soft melancholy. In private life nothing could exceed the simplicity of his character, except the animation and interest of his conversation. See *La Scienza della Legislazione*, Livorno, 1807, 5 tomes 8vo. This is the last Italian edition of Filangieri's great work. There is a French translation in 7 vols. 8vo, published at Paris in 1798, from the Neapolitan edition of 1784. The first two books have been translated into English, under the title of *The Science of Legislation*, from the Italian of Filangieri, and published in 2 vols. 8vo, Lond. 1806.

FILE, among mechanics, a tool used in order to smooth, polish, or cut metals. This instrument is of iron or forged steel, cut transversely in little furrows, with chisels and a mallet, and of a depth corresponding to the grain or touch required. After cutting the file, it must be tempered with a composition of chimney-soot, very hard and dry, diluted and wrought up with urine, vinegar, and salt, and the whole reduced to the consistence of mustard. Tempering files consists in rubbing them over with this composition, and in covering them with loam; after which they are put in a charcoal fire, and taken out by the time they have acquired a cherry colour, which is known by a small rod of the same kind of steel put in along with them. Being taken out of the fire, they are thrown into cold spring water, and subsequently cleaned with charcoal and a rag; after which they are kept dry and free from rust by laying them up in wheat bran. Iron filings require more heating than steel ones. Files are of different forms, sizes, cuts, and degrees of fineness, according to the different uses and occasions for which they are made.

FILIAL, something belonging to the relation of son.

Fi

Fil

Filial Piety.

Filial Piety, the affectionate attachment of children to their parents, including in it love, obedience, and assistance. These are duties prompted equally by nature and by gratitude, independently of the injunctions of religion; for where shall we find the person who has received from any one benefits so many or so great as children have from their parents? And it may be truly said, that if persons are undutiful to their parents, they seldom prove respectable in any other relation. Profane history furnishes many fine examples of this amiable virtue.

The Roman dictator T. Manlius having exercised great cruelty over the citizens, was cited at the expiration of his office to answer for his conduct. Amongst a number of things laid to his charge, he was accused of treating with barbarity one of his own sons. Manlius, according to Livy, had no other cause of complaint against this son than his having an impediment in his speech; for which reason he was banished from the city, his home, and the company of those of his own age and fortune, and condemned to perform servile works. All were highly exasperated against such inhuman conduct, excepting the son himself, who, under the greatest concern lest he should furnish matter of accusation against his father, resolved upon adopting a most extraordinary method to relieve him. One morning, without apprising any body of his design, he came to the city armed with a dagger, and went directly to the house of the tribune Pomponius, who had accused his father. Pomponius was yet in bed. Young Manlius sent up his name, and was immediately admitted by the tribune, who did not doubt but he was come to discover to him some new instances of his father's severity. But Manlius, as soon as he was left alone with the tribune, drew out his dagger, and presented it to his breast, declaring he would stab him to the heart on the instant, if he did not swear, in the form he should dictate, never to hold the assembly of the people for accusing his father. Pomponius, who saw the dagger glittering at his breast, and found himself alone, without arms, and attacked by a robust young man, full of confidence in his own strength, took the oath demanded of him, and afterwards confessed with a kind of complacency, and a sincerity which sufficiently showed that he was not sorry for what had happened, that it was this violence which obliged him to desist from his design.

Amongst the multitude of persons who were proscribed at Rome under the second triumvirate, were Cicero and his brother Quintus. But the latter found means to conceal himself so effectually at home, that the soldiers could not discover him. Enraged at their disappointment, they put his son to the question, in order to make him disclose the place of his father's concealment; but filial affection remained proof against the most exquisite tortures. An involuntary sigh, and sometimes a deep groan, was all that could be extorted from the youth. His agonies were increased, but with amazing fortitude he still persisted in his resolution of not betraying his father. Quintus was not far off; and it may be imagined how his heart must have been affected with the sighs and groans of a son expiring in tortures to save his life. He could endure no longer; and quitting the place of his concealment, he presented himself to the assassins, begging of them to put him to death, and dismiss the innocent youth, whose generous behaviour the triumvirs themselves, if informed of the fact, would judge worthy of the highest approbation. But the inhuman monsters, without being in the least affected with the tears of either the father or the son, answered that they must both die; the father because he was proscribed, and the son because he had concealed his father. Then a new contest of tenderness arose who should die first; but this the assassins soon decided, by beheading them both at the same time.

Cinna, who scrupled not to attempt any thing, however atrocious, which seemed calculated to serve his purpose, undertook to get Pomponius Strabo murdered in his tent; but his son saved his life; and this was the first remarkable action of Pompey the Great. The treacherous Cinna had, by many alluring promises, gained over one Terentius, a confidant of Pompey, and prevailed on him to assassinate the general, and seduce his troops. But young Pompey being informed of this design a few hours before it was to be put in execution, placed a faithful guard round the prætorium, so that none of the conspirators could come near it; then watched all the motions of the camp, and endeavoured, by acts of prudence worthy of the oldest commanders, to appease the fury of the soldiers, who hated the general his father. However, some of the mutineers having forced open one of the gates of the camp, in order to desert to Cinna, the general's son threw himself flat on his back in their way, crying out that they should not break their oath and desert their commander, without treading his body to death. By this means he put a stop to their desertion, and afterwards wrought so effectually upon them by his affecting speeches and engaging demeanour, that he reconciled them to his father.

Olympias, the mother of Alexander, was of such an unhappy disposition, that he never allowed her to have any concern in the affairs of the government. She used frequently to make great complaints on this account; but he always submitted to her ill humour with great mildness and patience. Antipater, one of his friends, having one day written a long letter against her to the king, then absent, Alexander, after reading it, replied, "Antipater does not know that one single tear shed by a mother will obliterate ten thousand such letters as this." Behaviour like this, and the answer here recorded, show that Alexander was both an affectionate son and an able politician.

Epaminondas is universally acknowledged to have been one of the greatest generals and best men whom Greece ever produced. Before him the city of Thebes was not distinguished by any memorable action, and after him it was more famous for its misfortunes than its virtues, till it sunk into its original obscurity; so that its glory may be said to have arisen and expired with this great man. The victory which he obtained at Leuctra had drawn the eyes of all the neighbouring states upon Epaminondas; they looked upon him as the support of Thebes, the triumphant conqueror of Sparta, and the deliverer of Greece; in a word, as one of the greatest men and the most excellent captains the world had ever produced. But, in the midst of this universal applause, so capable of making the general of an army forget the man, Epaminondas, little sensible of so affecting and so deserved a glory, observed, "My joy arises from my sense of that which the news of my victory will give my father and my mother."

Amongst an incredible number of illustrious persons who were falsely accused and put to death by Nero, was one Bareas Soranus, a man of singular vigilance and justice in the discharge of his duty. During his confinement, his daughter Servilia was apprehended, and, being brought before the senate, was there arraigned. The crime laid to her charge was, that she had converted into money all her ornaments and jewels, and the most valuable part of her dress, to defray the expense of consulting magicians. To this the young Servilia, with tears, replied, that she had indeed consulted magicians, but the whole of her inquiry was to know whether the emperor and senate would afford protection and safety to her beloved and indulgent parent against his accusers. "With this view," said she, "I presented the diviners, men till now utterly unknown to me, with my jewels, apparel, and the other ornaments peculiar to my quality, as I would have presented my blood and my life, could my blood and life have procured my father's liberty. But whatever this my proceeding was, my unfortunate father was an utter stranger to it; and if it is a crime, I alone am the delinquent." Notwithstanding this affecting appeal, she was condemned to die along with her father, but in what manner history is silent.

Valerius Maximus likewise mentions a very singular circumstance relating to this subject. A woman of illustrious birth had been condemned to be strangled. The Roman prætor delivered her up to the triumvir, who caused her to be carried to prison, in order that she might be put to death. But the jailor, who was ordered to execute her, being struck with compassion, could not resolve to kill her, and chose therefore to let her perish of hunger. Besides this, he suffered her daughter to see her in prison, taking care, however, that the former brought nothing in the shape of sustenance. As this continued many days, he was surprised that the prisoner should live so long without eating; and suspecting the daughter, he discovered, on narrowly watching her motions, that she nourished her mother with her own milk. Amazed at so pious, and at the same time so ingenious an invention, he mentioned the fact to the triumvir, and the triumvir to the prætor, who believed the thing deserved being mentioned in the assembly of the people. The criminal was pardoned, and a decree was passed that the mother and daughter should be subsisted for the rest of their lives at the public expense.

The same author gives a similar instance of filial piety in a young woman called Xantippe towards her aged father Cimonus, likewise confined in prison, and which is commonly known by the name of the *Roman charity*. Both these instances appeared so extraordinary to that people, that they could only account for them by supposing that the love of children to their parents was the first law of nature. *Putaret aliquis*, says our author, *hoc contra naturam factum esse, nisi prima naturæ lex esset diligere parentes.*

FILIBEG, or Philibeg. See Philibeg.

FILICAIA, Vincenzo da, a celebrated Italian poet, descended of a noble family of Florence, was born in that city on the 30th of December 1642. He commenced his studies under the Jesuits at Florence, and completed them in the university of Pisa. Grecian and Roman antiquity, philosophy, theology, and jurisprudence, were successively the objects of his study; poesy served merely as a relaxation from severer pursuits. Like most young devotees of the muses, he began with amatory verses; but the lady whom he loved and celebrated having died in the flower of her age, he burned all the verses which he had inscribed to her, and resolved henceforth to sing only heroic or sacred themes, a resolution which he most religiously observed. Having returned to Florence, after a residence of about five years at Pisa, he was received into the academy Della Crusca, and, in a short time, married a daughter of the senator Scipio Caponi; but as this lady brought him little fortune, and his own means were limited, he withdrew entirely from the world, on the death of his father, and established himself in the country, where he divided his time between his studies, the education of his children, and the contemplation of the wonders of nature and its author. He every day composed verses either in Latin or Italian, which he submitted to the judgment of his friends, and improved according to the advice which they gave, without any desire for publication, or indeed any other object than that of exercising his own powers. But a memorable occurrence drew him from the voluntary obscurity in which he had buried himself. Vienna, besieged by an army of two hundred thousand Turks, was delivered by John Sobieski, king of Poland, and by the Duke of Lorraine, afterwards Charles V. This great event, which saved Christendom from the most imminent danger, excited the enthusiasm of Filicaia, who, in a magnificent *canzone* or ode, celebrated the victory of the Christian armies; he also addressed a second to the Emperor Leopold I., a third to the King of Poland, a fourth to the Duke of Lorraine, and a fifth to the god of armies; and the Ottomans, having been entirely defeated in another battle, he celebrated this new triumph in a sixth ode, which is perhaps the most beautiful of all. These six triumphal odes excited universal admiration. The grand duke, of his own accord, sent copies of them to the princes whose exploits were commemorated, and from the latter the author received the most flattering acknowledgments. But as the copies of his odes became daily deformed by new errors, in proportion as they were multiplied, his friends at length obtained permission to print them. They accordingly appeared at Florence, in 1684, in 4to; and Filicaia was, almost in spite of himself, placed in the first rank of Italian lyric poets. Another great ode, which he addressed the same year to Queen Christina of Sweden, fully supported the reputation which he had gained by his former productions. This princess, who then exhibited in private life the generosity of a sovereign, did not confine herself to a mere expression of her satisfaction, or corresponding with the author, or admitting him into the academy, which she had formed at Rome, of men most distinguished in poetry and letters; being informed of the depressed state of his circumstances, she in some sort adopted his two sons, undertook to defray the expense of their education, and exacted from their father, as the only expression of his gratitude, that he would maintain the most profound silence, not chusing, as she said, to have to blush before the public for having done so little to serve a man who had so many claims to her esteem. But a severe malady with which he was seized some years afterwards, was followed by another subject of affliction, which he felt much more sensibly; he lost his eldest son, who had been appointed page to the grand duke after the death of the queen his benefactress. This bereavement, which he bore with Christian fortitude, fixed on him the particular attention of the prince, who, interested in his fortune, conferred on him the dignity of senator, and soon afterwards appointed him ducal commissary of Volterra, then commissary of Pisa, and, lastly, secretary *au tirage* to the magistrates, an important office, which gave him immediate access to the prince, and initiated him in the secrets of the government. Filicaia, in all his employments, secured at once the gratitude of the public, the attachment of those under him, and the esteem of his sovereign. Neither the multiplicity of his occupations, nor the progress of age, however, prevented him from dedicating several hours each day to the cultivation of letters and the exercise of his poetical talent; but as his piety, which had always been great, increased with his years, he at length confined his reading to religious books, and treated only of sacred subjects. Nevertheless, he had resolved to collect all his pieces, to revise and correct them of new, and to publish himself a complete edition of his lyrical composition; but, whilst occupied with this undertaking, in which he had made considerable progress, he was seized with a violent affection in the chest, which in a few days put a period to his life. He died at Florence, on the 24th of September 1707, in the sixty-fifth year of his age, and was interred in the family vault in the church of St Peter, where his son Scipio erected a monument to his memory. The edition of his poetical works in Italian, which he was preparing, and had even begun to print at the time of his death, was also speedily published by the same son, who dedicated it to the Grand Duke Cosmo III. under the title of *Poesie Toscane de Vincenzo da Filicaja, senatore Fiorentino et acceademico della Crusca*, Florence, 1707, in 4to. They were reprinted in

1720, with a life of the author, by Thomas Bonaventuri, a Florentine; which life had previously appeared in the second volume of the *Vite degli Arcadi Illustri.* But a more valuable though less beautiful edition, from which all the subsequent editions have been taken, is that of Venice, 1762, in two volumes 8vo; the first of which contains the *Poesie Toscane*, and the second, the Latin verses of the same author, there for the first time collected from the different publications in which they had been previously scattered. There are subjoined some pieces in prose of inferior interest, if we except a literary correspondence of Filicaia with Francesco Redi, Menzini, and Gori, who shared with him the glory of having, in a corrupt age, remained faithful to the principles of good taste and sound literature. The *canzoni*, to which we have above referred, are perhaps the most remarkable compositions in this collection; but some of the other pieces are not inferior to these either in the dignity of the subject or the majesty and force of the style; and several of his *Sonnets* are worthy of these beautiful odes. Is there an Italian heart that can be insensible to the deep patriotic feeling, expressed with such a mournful and affecting sublimity, in the well-known sonnet commencing

> Italia, Italia, O tu cui feo la sorte
> Donno infelice di Bellezza, etc;

one of the most perfect compositions of the kind in existence, and which, though it consists of only fourteen verses, will sustain a comparison with the most celebrated lyrical effusions, ancient or modern?

FILIGRANE, Filigree, or Fillagree, Work, a kind of enrichment on gold or silver, wrought delicately in the manner of little threads or grains, or both intermixed. The word is compounded of *fil* or *filum*, a thread, and *granum*, a grain, and in Latin is called *filatim elaboratum opus, argentum, aurum.*

There is no manufacture in any part of the world which has been more admired and celebrated than the fine gold and silver fillagree of Sumatra; and what renders it a matter of still greater curiosity, is the coarseness of the tools employed in the workmanship, and which, in the hands of an European, would not be thought sufficiently perfect for the most ordinary purposes. They are rudely and inartificially formed by the goldsmith, from any piece of old iron which he can pick up. When one of them is engaged to execute a piece of work, his first request is usually for a piece of iron hoop to make his wire-drawing instrument; an old hammer head, stuck in a block, serves him for an anvil; and his pair of compasses is often composed of two old nails tied together at one end. The gold is melted in a piece of *preeoo* or earthen rice-pot, or sometimes in a crucible of ordinary clay. In general no bellows are used, but the fire is blown with the mouth, through a joint of bamboo; and if the quantity of metal to be melted is considerable, three or four persons sit round the furnace, which is an old broken quallee or iron pot, and blow together. At Padang alone, where the manufacture is most considerable, they have adopted the Chinese bellows. The method of drawing the wire differs but little from that which is used by European workmen. When drawn to a sufficient fineness, it is flattened by beating it on the anvil; and when flattened, a twist is given to it like that in the whalebone handle of a punch ladle, by rubbing it on a block of wood with a flat stick. After twisting they again beat it upon the anvil, and thus it becomes flattened wire with indented edges. The end of the wire is folded down with a pair of pincers, and thus is formed a leaf, or element of a flower in their work, which is cut off. The end is again folded and cut off, till they have got a sufficient number of leaves, which are laid on singly. Patterns of the flowers or foliage, in which there is seldom much variety, are prepared on paper of the size of the gold plate on which the fillagree is to be laid. According to these, they begin to dispose on the plate the larger compartments of the foliage, for which they use plain flattened wire of a larger size, and fill it up with the leaves before mentioned. In order to fix the work, they employ a gelatinous substance, made of the red-hot berry called *boca sago*, ground to a pulp on a rough stone, which pulp they place on a young cocoa nut about the size of a walnut, the top and bottom being cut off. After the leaves have been all placed in order, and stuck on bit by bit, a solder is prepared of gold filings and borax moistened with water, which is strewed over the plate, when it is put in the fire for a short time, and the whole becomes united. This kind of work on a gold plate is called *carrang papan;* but when the work is open, it is called *carrang trouse.* In executing the latter, the foliage is laid out upon a card, or soft kind of wood, and stuck on, as before described, with the sago berry; and the work, when finished, being strewed over with the solder, is put into the fire, when the card or soft wood burning away, the gold remains connected. If the piece be large it is soldered at several times. In the manufacture of badjoo buttons, they first make the lower part flat, and having a mould formed of a piece of buffalo's horn, indented to several sizes, each like one half of a bullet mould, they lay their work over one of these holes, and with a horn punch press it into the form of a button; after which they complete the upper part. When the fillagree is finished they cleanse it by boiling it in water with common salt and alum, or sometimes lime juice; and in order to give it that fine purple colour which they call *sapo*, they boil it in water mixed with brimstone. The manner of making the little balls with which their works are sometimes ornamented, is simple. They take a piece of charcoal, and having cut it flat and smooth, make in it a small hole, which they fill with gold dust, and this being melted in the fire, becomes a little ball. They are very inexpert at finishing and polishing the plain parts, hinges, screws, and the like, being in this as much excelled by the European artists as the latter fall short of them in the fineness and minuteness of the foliage. The Chinese also make fillagree mostly of silver, which looks elegant, but wants the extraordinary delicacy of the Malay work. The price of the workmanship depends upon the difficulty or uncommonness of the pattern. In some articles of usual demand it does not exceed one third of the value of the gold, but in matters of fancy it is generally equal to that of the metal.

FILIPPO D'ARGYRO, a city of the province of Catania, in the island of Sicily. It is situated on the summit of a lofty insulated hill, abounds in churches and monasteries, contains 6118 inhabitants, and produces near it much saffron and good wine. It was the birth-place of the celebrated historian Diodorus Siculus.

FILLET, or Filet. See Architecture, *Index.*

Fillet, in *Heraldry*, a kind of orle or bordure, containing only a third or fourth part of the breadth of the common bordure. It is supposed to be withdrawn inwards, and is of a different colour from that of the field. It runs quite round, near the edge, as a lace over a cloak.

Fillet is also used among painters, gilders, and others, for a little rule or reglet of leaf gold, drawn over certain mouldings, or on the edges of frames, pannels, and the like, especially when painted white, by way of enrichment.

Fillets, in the *Manège*, are the loins of a horse, which begin at the place where the hinder part of the saddle usually rests.

FILM, a thin skin or pellicle. In plants it signifies that thin woody skin which separates the seeds in the pods, and keeps them apart.

FILOTI, a town of the Turkish province Yanina, and the capital of a district of the same name. It contains

4000 inhabitants, who make excellent oil, and cultivate a considerable extent of tobacco.

FILTER, an instrument or apparatus contrived for clearing liquids from any impurities mechanically combined with them. Filters are of various kinds, according to the nature of the liquor requiring to be clarified; but they all act on the same general principle, namely, straining the liquor by passing it through earth or other porous material; the process being thus exactly analogous to that of sifting, as used for powder or other dry substances. The operation of filtering is extensively used in chemistry and the arts, and also in purifying water for domestic purposes, and for the use of ships in long voyages; and hence the construction of artificial filters on a large scale for the supply of towns and cities with pure water becomes a very nice and difficult operation, and now forms an important branch of civil engineering. The pureness of spring water arises entirely from a process of filtration. Such water generally issues from a considerable depth beneath the surface of the ground, as is evident from the force with which it is discharged, and the equable temperature which it preserves throughout the year, being cool in summer, and in winter never freezing. Hence, in its course from the surface downwards, it must pass through a variety of soils, subsoils, and porous rocky strata; and it is by the perfect straining which it receives in percolating through such vast masses of filtering materials as must occur in the bowels of the earth, that it comes out at last with that admirable purity and transparency which we observe. But notwithstanding of this, spring water contracts, often among the rocks and minerals with which it comes in contact, various impurities, which become chemically dissolved in it, and from which it cannot be freed by filtration or any other mechanical process. It becomes often, therefore, unfit on this account for domestic use or the purposes of the arts, and is rarely equal, and never superior, to rain or river water properly filtered. The great importance of this operation, therefore, is evident, more especially from the frequent and serious failures which have taken place. But it may be better to defer the consideration of this branch of the subject till it can be resumed along with other hydraulic operations. See WATER-WORKS.

Water filters for domestic use.

On a smaller scale, for domestic use, water filters have at different times been brought forward, and for many of them patents taken out. But as they are all very similar in principle, and none appears greatly distinguished above the rest, it is unnecessary to enter into a minute description of them. They are all liable to the objection of clogging up, and getting foul in the course of time. But if regularly cleaned, any of them will answer the purpose sufficiently well, the process of filtration being so simple and so easily effected. Several ingenious plans have been proposed for self-cleaning filters; the water, for instance, being made to ascend, or to pass alternately in opposite directions, and thus carry off the impurities by the process itself. But as none of these have succeeded completely, it will be found most convenient in small filters to clean them regularly; and those are therefore to be preferred which afford the means of doing this most conveniently.

Filtering materials.

In these filters the filtering material generally used is gravel, sand, porous stone, or unglazed earthenware. Charcoal is sometimes added, but this is more for its antiseptic and purifying quality, and is only necessary in the case of fetid or very impure water. Gravel, though the best of all materials on a large scale, is rather coarse in itself for small filters. But where it occurs in nature in very thick beds, the large mass of material makes up for the coarseness of the grain; and many instances occur where springs from this source are scarcely inferior in purity to distilled water. But in small filters it requires a bed of sand above it to detain the impurities. Sand is perhaps, after all, the best filtering material; it should, however, be clean sea or river sand, with no tincture of iron; this last is indicated by its reddish colour, which, if deep, will communicate an iron taint to the water, a circumstance harmless enough in itself for most domestic uses, but very prejudicial for the purposes of bleaching, paper-making, &c. in the arts.

Sand, gravel ters.

In filters constructed with gravel or sand, all the apparatus that is necessary is a vessel to contain the filtering material, with a space above for holding a quantity of the water to be filtered, and a vessel below for receiving the filtered water. A simple and convenient apparatus of this kind was contrived by Messrs Hearman and Dearn, potters, Redriff, described in Nicholson's *Journal*, vol. viii., and represented in Plate CCXLV. fig. 1, which exhibits the whole apparatus, and shows, in fig. 2, a shaded section. A is a vessel of stone-ware perforated with holes, *m*, at bottom, upon which coarse gravel, *h*, is laid, and on that again a stratum of fine gravel, and, lastly, fine sand, *g*. Or, otherwise, the bottom may be covered with a coarse cloth, which will render the graduated fineness of the gravel and sand less necessary. Upon the top of the sand is laid a perforated and loaded board or plate of earthenware, to prevent the sand from being disturbed when the water is poured in. B is a lower vessel, into which the filtered water from A drops, together with any sand that may escape from above. The clear water flows out through the neck *ac* into the vessel *d* for use.

On this plan an excellent filtering apparatus may be constructed at little expense, and in various ways, according to the means or conveniencies most readily at hand; and the sand and gravel possess a decided advantage over filtering stones or other materials, from the great facility of cleaning, the latter being liable, from long use and the impurities lodging in their pores, to give the water an unpleasant taint.

A very simple arrangement in the above plan is to have a cylindrical jar of earthenware, as at fig. 5, with two partitions or false bottoms, dividing the height into three equal portions, the partitions resting each on a shoulder formed all round on the jar, or otherwise supported; the middle division for the filtering material, the upper one for the water to be filtered, and the lower one for containing the filtered water, with a stop-cock for drawing it off at pleasure, and a vent or opening at the top for the admission and discharge of air. The stop-cock must be placed three or four inches from the bottom, to allow full space for any sand or other material to deposit in the bottom; and the air vent must be carried up by a small pipe to the top of the jar, to prevent the water ever rising and overflowing by it. The partitions are made of earthenware, with a number of small holes to allow the water to descend. If sand only is used, it will be necessary to spread a layer or two of cloth under it, to prevent the sand getting through the openings. But if gravel can be had, it will be better to lay a bed of this, of two inches or more in thickness, on the bottom, and the sand above it. After the sand is filled in to the height of the upper partition, this is placed on as a cover, which having also a number of small openings in it, the water flows from the upper division downwards. The cover should press on the top of the sand, in order to prevent its being disturbed by the entrance of the water, or a layer of gravel should be placed on the top of the sand. If a layer or two of cloth be laid over the partition, it will serve to detain some of the impurities; and being frequently washed, it will make the filter continue longer clean. In order to clean this filter it is only necessary to remove the upper partition, take out the upper stratum of sand to the depth of two or three inches, wash it thoroughly, and replace it; or, if sand can be had readily, let the whole be replaced with a fresh quantity, clean and pure. This is, on the whole, a very simple, perfect, economical, and convenient filter. It may be constructed of wood or other convenient material, and is both very easily formed, and easily kept clean and in order; and by varying the thickness of the bed of sand, it can be adapted to the exact degree of filtration required. The vessel also admits of any ornamental shape which taste may direct; and several elegant figures of this kind, contrived by the manufacturers, are shown at the bottom of the plate. If the lower division also were left unglazed and porous, an evaporation would go on from the outside, so that in summer it would act as a cooler as well as a filterer. Should much sediment be found collecting in the lower vessel, perhaps it would be better to place the whole apparatus upon a second jar, so wide as to allow the first to stand over it, and having a pipe in the bottom rising nearly to the top of the vessel, and open at the top. The filtered water would flow over this, and descend into the lower vessel, which being detached, could always be kept perfectly clean in the bottom. The upper end of the pipe should be covered with a fold or two of cloth. An ingenious plan, introduced by Mr Parkes, chemist, for drawing off the water in the reservoir of a filtering or purifying apparatus, though applied rather on a larger scale, might often be used with advantage in smaller filters, such as those for bleachers, paper-makers, and others. It is represented at fig. 6, and consists in connecting the stop-cock for the discharge of the water with a pipe and flexible joint terminating in a rose-head and floating ball, which keeps the head always immersed a little under water, and thus discharges it from near the surface, although the level of the water may vary considerably. The water here is also let in, not directly into the reservoir, but by an upright pipe having a funnel at the top, and descending to near the bottom, which causes the water to enter below, where it must deposit any impurity before this can rise to the surface.

Filterin by desc and asce

In the sand and gravel filters here described, the water descends during the whole of the process, and this causes a slight tendency to carry minute particles of sand or other impurities along with it. To remedy this defect, various plans have been proposed for making the water, after descending, again ascend; and this plan certainly possesses advantages, and is a decided improvement on the other. A very neat contrivance of this kind is that proposed by Professor Parrot of Paris, in Nicholson's *Journal*, and is represented at fig. 3.

By Pro sor Parr

It consists simply of an inverted syphon, which could be easily made of lead, having the bend filled with sand, and being covered on the top with gravel in each branch. The water entering the longer branch from a reservoir, passes through the sand, and rising up, is discharged at the other end, which should be three inches below the level of the first. When the section of the tube is four inches by two, and eighteen inches the length of sand, it was calculated that six Paris pints of pure water would be passed in an hour.

By Sir Englefie

Another plan, proposed by Sir Henry Englefield, in the same work, is shown at fig. 4. It consists of a conical vessel placed within the one containing the sand, and allowing the water to descend on the inner vessel, and ascend again in the outer one.

But the simplest mode of effecting the ascent of the water is merely to divide the jar or filtering vessel by a vertical partition, open at the bottom. The water being then poured into the one side, descends to the bottom, passes under the partition into the other side, and ascends to the same level at which it entered, and can then be drawn off by a stop-cock or other means at pleasure. In that case a single vessel only is wanted, and contains in itself the means of holding separately the filtering material, the water to be filtered, and the water after filtration. Upon the whole, this appears by far the simplest, most perfect, most economical, and most convenient filter of this, or perhaps of any kind, that can be contrived. All that is necessary is to have a pretty deep vessel of earthenware, wood, or other material; a tub or barrel will answer perfectly. Put a vertical partition in the middle, reaching nearly to the bottom, fill it half or three fourths full of sand, with a layer of gravel on the top, and it is ready for use. It may be found convenient, to prevent the gravel being disturbed, to place a cover over it, with holes. The water may either be drawn directly from the pure side with jugs, or let off by a stop-cock. Instead of sand and gravel, some have proposed to use charcoal, either by itself or in combination with the others; and an apparatus of this kind was contrived by Mr John Isaak Hawkins. It is only, however, when the water has an impure taint, which cannot be removed by sand, that the charcoal should be resorted to, as it is more expensive, and more difficult to be cleaned. In long voyages, however, charcoal, as proposed by Hawkins, may, in conjunction with sand, be found very useful.

Charcoal filter by Mr Hawkins.

Filtering by ascent alone.

Instead of the water descending and then ascending, several ingenious methods have been contrived where the water only ascends through the filter, being let in below, and forced upwards by the pressure of an external head of water. The advantage of this is, that the filter can be cleaned by letting the water return and run out at the place where it usually enters. These plans, however, on a small scale, are hardly ever found to supersede cleaning. On this principle was the patent granted in 1791 to Mr Peacock, which he intended for small filters as well as those on a large scale. His apparatus consisted of a vessel of wood, lead, or other materials, of any shape or dimensions required, divided near the bottom by a horizontal grate or partition, upon which the filtering medium was spread in layers, beginning with the coarsest and ending with the fine. The lower division had a communication with a more elevated reservoir, from which the water flowed, and rose through the filtering bed. This consisted of gravel, sand, broken and pulverized glass or pottery, all well washed and sifted with sieves. On a similar principle Mr Bramah had a patent for various modes of conveying and drawing off beer and other liquors, in which he describes a filtering apparatus which he proposed to place in the pipes to conduct the liquor. This was a cylindrical vessel, made of copper tinned within, or of any other materials; the upper end was closed by a lid screwed on by a flaunch, and the lower end terminated in a cone; a pipe was inserted into the vessel near the lower part, to introduce the liquor; and from near the upper end a similar pipe proceeded to convey it away. Between these two was fixed the filtering floor, consisting of flannel, sand in bags, sponges or other similar substances, which were spread upon a horizontal plate pierced full of small holes, and fixed in the cylinder above the filtering substance; and another similar plate was fixed and screwed down to confine it. The liquor was introduced by the lower pipe by means of a pump or otherwise, and ascending through the filtering floor, passed off in a clarified state; the impurities which are separated collect in the conical bottom of the cylindrical vessel, whence they can be drawn by a cock. This contrivance is adapted to give a slight filtration to a great quantity of liquor, such as beer; and Mr Collier, in a patent for the purification of oils, claimed the principle of filtering *per ascensum* combined with hydrostatic pressure.

Mr Peacock.

Mr Bramah.

Mr Collier.

Filtering stones.

Such are the different contrivances for filtering water, where sand and gravel are the materials; but notwithstanding their simplicity, filters of porous stone are those which have hitherto been most generally in use. The stones are procured from beds of sandstone, and sometimes a kind of limestone. They are found in Northamptonshire, Derbyshire, and other parts of England, and are often imported from the island of Teneriffe. The construction of the filter is extremely simple. A thick bowl or basin is formed of the stone, and mounted in a frame. The foul water, being poured into the basin, passes slowly through the substance of the stone, and drops into a receptacle below, in a perfectly transparent state. When the water is foul, a small quantity of mud or slime is found to collect at the bottom of the basin, and must occasionally be cleared out; but in the course of time the more minute impurities will insinuate themselves into the pores of the stone, and at last clog up the passage of the water. This is remedied by chipping away the interior surface of the stone one half or three fourths of an inch, because the impurities do not penetrate deeper into the stone. This will restore its action for a long time.

The basin shape used in these filters is obviously not the most proper, as it leaves an unequal thickness in the bottom for the water to penetrate, and also the pressure of the fluid is unequal. The bottom should be flat and of equal thickness, and in fact it would be much better not to make the stone a reservoir at all; but to use a filtering vessel such as above described, substituting for the sand and gravel a plate of the filtering-stone, of such thickness as may be found best adapted for the nature of the water. If a thin plate also were placed on the top of a thick one, it might then be removed without any trouble when it got foul, and replaced by another, without disturbing the lower mass; or several plates could be laid one above another till the requisite thickness for filtering were obtained.

Filtering upwards.

Instead of pouring the water into the basin and allowing it to filter downwards, the water may be contained in a vessel in which the basin is nearly immersed; and in this way the water will filter partly laterally, but chiefly *per ascensum*, and leave much of its deposit behind, so as to enable the stone to continue longer clean. A filter on this plan was contrived by Mr Moult, and is described in the Transactions of the Society of Arts. The filtered water runs in and fills the basin, from which it can be taken out or let off by a pipe. This principle was also proposed by Mr Collier, and it possesses all the advantages we have already described in filtering upwards with sand; and if it were used with plates of the stone instead of a basin, it would be still more effectual.

Anglesea earthenware filters.

The unglazed earthenware for filtering has been introduced as a substitute for the filtering stones. It is made of different compositions of pottery. The original patent was granted to Mrs Johanna Hempel, potter, Chelsea, in the year 1790. The proportions were four out of nine of tobacco-pipe clay, and five out of nine of coarse sea, river, or pit sand. This was intended for basins not exceeding one gallon. For larger capacities it is liable to fly or crack in the fire. A second composition, therefore, consisted of equal parts of tobacco-pipe clay and sea or river sand; or if this was found insufficient to prevent the cracking, three parts tobacco-pipe clay, one of Stourbridge clay, or clay from the surface of the coal mines, one of Windsor loam, or other loam of equal quality, and four of coarse river or sea sand; or four parts of tobacco-pipe clay, three of sand, and one of the burnt ground clay of which crucibles are made. The above ingredients are brought to the proper basin or bowl shape on the wheel, and are then hardened in the furnace like other pottery ware. The same objection, however, applies here to the basin shape as to the stones; in fact, it would be better to have this composition formed into plates of different thickness, which could then be used, one or more in number, in the filtering vessels, instead of sand or stone; one could be taken out when foul, and another put in, with the utmost facility; and this would certainly be attaining the perfection of a filtering apparatus.

Another still simpler plan would be to have one filtering vessel, with a vertical partition of the porous ware reaching to the bottom. The one half of the vessel would then be filled with the impure and the other with the pure water; and if several of these plates were at hand, one partition could be taken out when foul, and another inserted in its place, or there might be two porous partitions, and a solid one between them. The one would then ascend and run over the top of the solid partition, and again descend and pass through the second porous partition, which would therefore hardly ever require renewal.

A filter by Mr Robins of London, and for which he has taken out a patent, has been lately much recommended to the public. The external appearance is varied according to taste, and figs. 13, 14, 15, already referred to, represent some of the neatest and most elegant patterns. We are not acquainted with the interior construction, but understand it consists of various strata of filtering material, such as we have above described, arranged so as to act with peculiar efficacy. At the top there is a sponge neatly inserted into a recess above the upper partition, which is a very judicious and useful mode of detaining any impurities, and preventing them from getting into the filterer, the sponge being easily taken out and washed from time to time. The patentee, however, claims far higher powers for his invention than that of mere filtration. He states that the interior process involves a *voltaic* action, which decomposes soluble substances, and renders the water equal in purity to distilled water. We confess we have great doubts in regard to this, and think it irreconcilable with any idea of voltaic or chemical action with which we are acquainted. Still we have no doubt, from the various testimonials brought forward, that the filter is a good one. Fig. 14 is about three feet high, and one and a half broad, and is calculated to filter fifty gallons a day; the others in proportion.

From the great success with which water has been purified by filtration, attempts have been made to purify oils in the same manner; and an ingenious apparatus for this purpose was contrived, and a patent taken out, by Mr Joshua Collier, applicable also to water and other liquids, and of which an account will be found in the *Repertory of Arts*, vol. x. But in oils there is generally so many impurities, chemically or otherwise united, that filtration can do little for their purification. Charcoal is the substance chiefly employed. A filtering machine contrived by Mr Innes of Edinburgh is said to answer well for oils and other fluids. By it the fluid is forced through the pores of wood by the action of a forcing-pump. Such a degree of pressure is unnecessary for water; but for oil, quicksilver, and other valuable fluids, it appears certainly well adapted.

Filtration is much used in chemical processes. The materials employed are unsized paper, cloth, flannel, tow, sponge, sand, pulverized glass, flints, porous stones, earthenware, &c. In fig. 12 is represented a neat little filtering apparatus constructed by Mr Parkes; and the following remarks and directions are taken from Mr Faraday's excellent work on Chemical Manipulation. "Of the above substances, the first is almost exclusively in use at the laboratory, a few of the others now and then being resorted to only on particular occasions.

"Funnels are continually necessary to support the paper through which filtration is to take place. The ordinary funnels required in the laboratory for the passage of fluids answer the purpose very well, but they are of use for supporting filters, when, from their necks being broken off, they are otherwise unserviceable. They may be either of glass or good Wedgewood or other earthenware; those of glass are to be preferred, because the progress of the filtration and the state of the filter can be better ascertained in them. Metal funnels should not be allowed in the laboratory.

"The funnels containing filters may be frequently supported by the glass or jar intended to receive the filtered fluid, and at other times by the rings of retort stands. But notwithstanding these facilities, so frequently is the operation required, a laboratory should be supplied with at least one filtering stand of considerable size. The end of such a stand is represented in fig. 7. It should be fifteen inches wide, three or four feet long, and have an interval between the bottom and top of twelve inches. The top should have a number of round holes made in it at intervals of six inches, differing in diameter from one and a half to three inches; two or three small ones of half an inch or an inch in diameter being intermixed. The whole should be well made and firm, so as to support considerable weights, the top having frequently to answer the purpose of a table, and to sustain jars full of solutions, as well as to bear funnels and filters.

"It is no easy matter for the chemist to obtain unobjectionable filtering paper, and yet it is of such importance in reference to the duties it has to perform, that he should not spare pains to procure the best possible. It should be so porous as to admit the free and ready passage of fluids; so close as to retain the finest solid particles; so strong as to bear the weight of a considerable quantity of fluid; and so pure as to give nothing to the solution, or if heated with the substance retained upon it, to occasion no mixture of ashes. Some chemists use plate paper, that is, the paper of copperplate printers. It is very porous, and yet there are few precipitates that will pass through it; at the same time it is often tender, generally yields a considerable quantity of ashes when burnt, and is inapplicable for minute filters when very small quantities of fluid only are to be worked upon, because of its thickness, and consequent waste of the portion of solution imbibed by it.

"It is amongst the thinner varieties of unsized paper, or white blotting paper, kept by some of the stationers, that the chemist will probably find the kind best suited to his purpose. It should be so strong, that a single filter of it, capacious enough to hold a pint of water, should not break with that quantity, even though some degree of agitation be given to the funnel containing it. Its porosity, that is to say, its comparative freedom from size, for it is mostly sized in a slight degree, may be judged of by holding it to the tongue, and observing how it absorbs moisture; and by a cautious pull its strength may be ascertained whilst in such moistened state. The student who is unused to the examination of papers will, however, better judge of its capability of allowing fluid to pass, by actual trial with water; a pint filter filled with clean water should allow the fluid to run in a considerable stream.

"The best method of judging of the purity of paper is to burn it and examine its ashes: the fewer it yields the better is it adapted for filters. A demy sheet should not yield more than one and a half or two grains of ashes altogether. If it contains more, their solubility or insolubility should be observed, that the student may be aware of the impurities that may probably be imparted to solutions in very delicate experiments. In minute cases of investigation, sulphuric acid may frequently be traced to the sulphate of lime existing in the filtering paper.

"Filtering paper should be cut ready for use into different sizes. A demy paper furnishes useful sizes for filters, when the sheet is separated into four, or six, or nine parts; and parcels of each of these sizes being prepared, they should have a string passed through the corners, and be preserved for use in a clean place. The previous cutting of the paper in this way is very convenient, as readily supplying the sizes that will be wanted, and in preventing the waste that would occur by carelessly tearing up a sheet each time a filter is required.

"On preparing a filter, the piece of paper should be first examined, by looking through it against the light, to ascertain that it is free from holes. The simplest filter is made by folding the paper twice in opposite directions, so as to bring the four corners together, and by opening one corner from the other three, so as to produce an irregular conical cavity, as in fig. 8. Such a filter being put into a funnel, and then filled with liquid, will immediately permit its passage; but from the similarity of form between the filter and the funnel, and the close adhesion of the former to the latter over by far the greater part of its surface, considerable obstruction is opposed to the passage of the fluid, and the operation is retarded. For this reason different contrivances have been recommended, to separate the filter here and there from the funnel, and allow passages for the fluid. Lavoisier recommended small glass rods inclined along the funnel before the filter is put in. Straws are used in a similar way, and they certainly open channels in their immediate neighbourhood, by which the fluid may flow down. By other chemists ribbed funnels are recommended; but it is difficult to find a funnel so deeply ribbed as to support the paper in such a manner that it shall not touch the glass in every part, and if they do not perform this they are of no use.

"The best expedient by far is so to fold the filter that ribs may exist in the paper itself; and this may be done so as not only to allow numerous free passages for the fluid between the filter and the glass, but also to allow of ready transmission through its whole surface, and not of one half only, and even that imperfectly, as in the former case. For this purpose, the paper is first to be doubled, and in this state is again to be folded in half, each half folded into quarters, and each quarter into eighths, the folds being all on the same side, and radiating at equal distances from the middle of the folded edge to the other edges. Fig. 9 represents the doubled paper thus divided into eight parts. Each eighth is now to be divided into half by folds in the opposite direction, but in lines still originating at the same centre, which makes the doubled piece resemble a child's paper fan, both when closed and when a little open: it is represented by fig. 10. Whilst in this state, the projecting corners should be taken off by a knife; folding the whole up tight like a closed fan, and making the section at about *a*. Being now allowed to expand a little, the originally doubled sides are to be separated from each other for the first time, but without disturbing the angles or bending the ridges or ribs which they form. Having opened it sufficiently to separate the cut edges from each other, it will be found that the paper is equally divided into parts forming alternate external and re-entering angles, except at the two edges *bb*, where two external angles come together. Here the intervening portion of paper between the two contiguous external angles should be folded, by bringing the latter together, and creasing the paper down, so as to form a re-entering angle between them: this should be done at both places. Then opening the paper sufficiently to bring the bottom into proper shape, by thrusting out the part which is convex within, so as to make it project externally, the filter is completed, and being put into a funnel, is ready for use. Its appearance, when perfectly formed, is represented at fig. 11.

"It is necessary, in making these filters, that the folds be not continued to the point, but that they should stop about half an inch short of it; for if completed to the bottom, the frequent action of the fingers in folding will so far break down and destroy the texture of that part, that a hole probably will appear before the filter is finished; or if not, it will be so weakened as to be unable to bear a quantity of fluid without breaking. Hence that part of the filter will, during the folding, assume a concave form; and the regularity of the folds, which by practice may be easily attained, must be strictly attended to in the upper part, but may be dispensed with at the lower. When opened out, therefore, for the completion of that part, before the filter is put into the funnel, all that will be required is to push that side of the bottom outwards which is convex inwards, doing it so carefully as to cause no injury. The folds of the filter should be distinct and sharp, an effect which should be obtained by a single decisive pressure, and not by much fingering. No wrinkle or mark should appear in a well-made filter, except the folds described, and the portion of paper between the folds should be as stiff as when first taken up. The filter should be handled lightly during the whole of the operation, and never be opened out more than is represented in the last figure. It is best to keep the folds as close, and the whole filter as compact, as possible, dropping it loosely into the funnel, and permitting the fluid poured in to do the office of opening it out. It should be so regularly made, that when thus expanded by the fluid, the external angles of the folds should touch the glass at equal distances from each other, except at two opposite places where smaller divisions exist; and unless a large quantity of fluid be present, the angles at the upper part should remain nearly as sharp when the liquid is introduced as they were before. Below they gradually pass into the rounded surface, forming the centre or bottom of the filter, which will be about the size of a sixpence or shilling, according to the dimension of the funnel in that part. These filters leave such free space between themselves and the glass, as to admit of the passage of a far greater quantity of fluid than is necessary; and no obstruction being placed against the external surface of the paper, the whole acts in the filtration, and that in the most favourable manner.

"Of these two kinds of filters, which may be distinguished as the *plain* and the *folded*, sometimes the one and sometimes the other is preferable. When the object is to cleanse and purify the fluid, that being the valuable part, it is most rapidly and effectually attained by a folded filter; but when the precipitate is the part required to be taken care of, it is generally desirable not to spread it over the irregular and extensive surface of such a filter, but, by using a plain one, to retain it on a surface of only half the extent. It is then likewise of such uniform thickness in every part, as best to admit of the operation of washing by having successive portions of water passed through it, and when the filter is opened out, the precipitate is delivered in one continuous portion, and not divided into many parts, as happens with the folded filter.

"When a single filter is judged too weak to hold the mass of fluid it is required to sustain, a double one should be used. If the filter is to be a folded one, then a double thickness of paper is to be taken; but if plain filters are used, the two should be made separately, and put one into the other, in such a manner that the three thicknesses of the one may come against the single thickness of the other. Occasionally it is proper to strengthen the bottom of the filter, which, not being supported by the glass, has to support the greatest column of fluid; but not so as to obstruct the upper part, where a filtration as free as possible is required. In such a case a smaller filter is to be added to the exterior of the large one, so that it may not interfere with the precipitate within, when it is necessary to remove it from the paper.

"The filter and funnel being ready, and placed on the stand in one of the holes before mentioned, over a glass ready to receive the liquid, the mixture to be filtered is to be poured in. It should not be poured from a great height, nor upon the middle of the filter, but down the side, the force of its descent being diminished as much as possible by good management, lest it break a hole through the paper: for the same reason it is better to pour it down the rod. If the first portions of fluid which pass be not clear, they should be returned into the filter, and a second glass should be placed beneath. The solid matter in the liquid to be filtered will soon, by adhering to the paper, cause clear filtration, except perhaps in one or two particular cases, as with precipitated oxide of tin, &c. on which occasions a double thickness of paper must be used. On changing the vessels beneath the filter for the removal of the clear solution, it should be done so that no drop be lost. By inclining the empty vessel, its edge may be brought under the funnel before the full one is removed; and in no case should a vessel be left under the filter, in which there is not sufficient room for the contents of the latter if it should break. Such an accident ought not to occur, but ought always to be provided against.

"Sometimes hot filtrations are to be performed. Oils filter better hot than cold: tallow and cocoa-nut oil may be passed through paper when hot; and many solutions must be filtered at high temperatures, because of the greater solubility of the ingredients under those circumstances. In these cases the fluids should be heated in a flask or basin before they are poured into the filters, and the filter funnels being placed in the glasses or jars, and, after the fluid is poured in, covered over with a basin or glass plate, the whole should be enveloped in a piece of flannel or a dry cloth. If, from the length of the operation, or other causes, the flannel or cloth be not sufficient, it may be dispensed with; and the glass and filter being placed on a warm part of the sand-bath, should be covered with a box or vessel large enough to rest on the sand, and thus form a hot air-chamber for the process. When the operations are upon a small scale, a paper cone is sufficient to cover the vessels on the sand-bath, and keep them hot.

"When the object is hastily to filter a fluid for the purpose of removing pieces of dirt, then a little loose tow at the bottom of a funnel, or a piece of sponge slightly thrust in, is often sufficient for the purpose. Upon some few occasions filters for acids are required. These are generally recommended of powdered glass, being arranged somewhat in the manner described for lixiviation. Pieces of glass are put into the neck of the funnel; upon these smaller fragments, then again other layers of particles diminishing in size, until a moderately fine powder has been used, the top being finished with a layer of small fragments, to prevent disturbance by pouring. The pieces of glass should be well cleaned before pulverization, and, when arranged, some water should be passed through the filter, to remove alkali or other matters that may be separable from the glass, which should be that of wine-bottles, and not flint glass.

"Another mode of separating a fluid from the finely-divided solid matter it may contain, is to allow the latter to deposit, and then to remove the former. This is called *decantation*, and is a process much superior to filtration in many analytical experiments, and recommended in preference both by Lavoisier and Berzelius."

For further information on this subject see *Repertory of Arts;* Hempel, vol. ii. p. 230; Collier, vol. x. p. 389; Peacock, vol. xi. p. 221, vol. xiii. p. 140; Nicholson's *Journal;* Hearman and Dearn, vol. viii. p. 126; Parrot, vol. ix. p. 40; Sir H. Englefield, vol. ix. p. 95; Lillach, *Phil. Mag.* vol. vi. p. 240; *Mém. Acad. Par.* 1745, Hist.

82; 1748, Hist. 121; *Machines Approuvées*, tom. vii. p. 280; Gilbert's *Journal der Physik*, vol. xiii. p. 108. (c.)

FIN, in *Natural History*, a well-known part of fishes, consisting of a membrane supported by rays, or little bony or cartilaginous ossicles.

FINAL, in general, whatever terminates or concludes a thing; as *final* judgment, *final* sentence, and the like.

FINAL *Cause*, is the end for which a thing is done. The final cause is the first thing in the intention of an agent, and the last in the execution.

FINAL Letters, among Hebrew grammarians, five letters so called, because they have a different figure at the end of words from that which they have in any other situation.

FINALE, a sea-port in the duchy of Genoa, and kingdom of Sardinia. It is divided into two parts, one called the Hill, the other the Marina. It is strongly fortified, especially against maritime attacks. The inhabitants amount to 3974, who carry on a brisk trade in olives and in oil, which the surrounding district copiously supplies.

FINANCES, in political economy, the revenues of a king or state; analogous to the treasury or exchequer of the English, and the *fiscus* of the Romans. The word is derived from the German *finantz*, scraping or usury; though Du Cange chuses rather to deduce it from the barbarous Latin *financia, prestatio pecuniaria*. See TAXATION.

FINCH, HENEAGE, first Earl of Nottingham, and Lord High Chancellor of England, was the son of Sir Heneage Finch, recorder of London, and born in December 1621. He received his education at Westminster school, and at Christ Church College, Oxford, of which he was a gentleman commoner; and he studied law in the Inner Temple, where, by his talents and diligence, he became remarkable for great legal acquirements. On the restoration of Charles II. he was made solicitor-general, and created a baronet. He was also appointed reader of the Inner Temple, and chose as his subject the statute of the 39th Elizabeth, concerning the payment and recovery of debts of the crown, which he treated with great force of reason and depth of legal erudition. As solicitor-general, he took an active part in the trials of the regicides; and, in 1661, he was chosen member of parliament for the university of Oxford, by the recommendation of Lord Clarendon; but, according to the author of *Athenæ Oxonienses*, he did his constituents no good, when they wanted his assistance for taking off the tax upon hearths. In 1665, after the prorogation of the parliament which then sat at Oxford, he was created doctor of civil law in full convocation; but after the ceremony had terminated, the public orator, being called upon to do his duty, stood up, and, in allusion to the tax above mentioned, observed, "that the university wished they had more colleges to entertain the parliament men, and more chambers, but by no means more chimneys;" an expression of academical opinion which, however undignified in itself, startled the new-made doctor of laws, who changed colour, and seemed by no means to relish the quaint remark of the orator. In 1667, when Lord Clarendon was impeached for certain alleged high crimes and misdemeanours, Sir Heneage, mindful of his old friend, stoutly defended him against the charges preferred by his enemies. In 1670 he was appointed attorney-general, and, some years afterwards, lord keeper. He was then raised to the peerage by the style and title of Baron Finch of Daventry, in the county of Northampton; and, in 1675, appointed lord high chancellor of England. He officiated as high steward at the trial of Lord Stafford, who, in the madness of that time, was found guilty of high treason by his peers, on a charge of being concerned in the Popish plot. In 1681 he was created Earl of Nottingham, and died, the following year, at his house in Queen Street, Lincoln's-Inn-Fields, from the exhaustion produced by long-continued exertion. Lord Nottingham was distinguished for both sagacity and eloquence; and though he lived in times when it was difficult to pursue a steady and consistent course, he conducted himself in such a manner as to retain the favour of the court without forfeiting the approbation of the people. "He was a person," says Mr Justice Blackstone, "of the greatest abilities, and most incorrupted integrity; a thorough master and zealous defender of the laws and constitution of his country; and endued with a pervading genius that enabled him to discover and pursue the true spirit of justice, notwithstanding the embarrassments raised by the narrow and technical notions which then prevailed in the courts of law, and the imperfect ideas of redress which had possessed the courts of equity. The reason and necessities of mankind arising from the great change in property, by the extension of trade, and the abolition of military tenures, co-operated in establishing his plan, and enabled him, in the course of nine years, to build a system of jurisprudence and jurisdiction upon wide and rational foundations, which have also been extended and improved by many great men who have since presided in Chancery; and from that time to this, the power and business of the court have increased to an amazing degree." In the name of the Earl of Nottingham have been published, 1. Several Speeches and Discourses on the trials of the Regicides; 2. Speeches delivered in both Houses of Parliament; 3. Speech at the Sentence of William Viscount Stafford, 7th December 1680; 4. Answers to his Majesty's command upon several Addresses presented to his Majesty at Hampton Court, 19th May 1681; 5. The Arguments upon which he made the Decree in the cause between the Honourable Charles Howard, plaintiff, Henry Duke of Norfolk, Henry Lord Mowbray his son, Henry Marquis of Dorchester, and Richard Marriot, Esq. defendants, folio; 6. An Argument on the claim of the Crown to pardon on Impeachment, folio. He also left in manuscript, *Chancery Reports*, and notes on Coke's *Institute*. (A.)

FINE, that which is pure and without mixture. The term is particularly used in speaking of gold or silver.

FINE, in *Law*, has different applications. Sometimes it is used for a formal conveyance of lands or tenements, or of any thing inheritable, being *in esse temporis finis*, in order to cut off all controversies. Others define it a final agreement between persons, concerning any lands, rents, or other subjects, of which any suit or writ is depending between them in any court.

FINE sometimes signifies a sum of money paid for entering lands or tenements let by lease; and sometimes a pecuniary mulct for an offence committed against the king and his laws, or against the lord of the manor.

FINE-Drawing, or *Rentering*, a dexterous sewing up or rejoining the parts of any cloth, stuff, or the like, torn or rent in the dressing, wearing, or otherwise.

FINE-Stiller, in the distillery. That branch of the art which is employed in distilling spirit from treacle or other preparations or recrements of sugar, is called *fine-stilling*, by way of distinction from malt-stilling; and the person who exercises this part of the trade is called a *fine-stiller*.

FINERS *of* GOLD *and* SILVER are those who purify and separate these metals from other coarser ones, or their ores, by means of fire and acids. They are also called *parters* in our old law books, and sometimes *departers*.

FINEERING. See VENEERING.

FINGAL, king of Morven, in ancient Caledonia. See OSSIAN.

FINKENWERDER, an island in the river Elbe, belonging to the kingdom of Hanover, in the bailiwick of Harburg, and between that city and Hamburg. It is fertile, and contains a small town of the same name, with 560

Finisterre || Finland.

inhabitants, who furnish the market of both cities with fruits and vegetables.

FINISTERRE, a maritime department of France. It is bounded by the sea on three sides, and on the east by the departments of the Côte du Nord and of Morbihan. It is in the shape of a triangle, and extends over 2890 square miles, or, according to the Almanac-Royal, 693,384 hectares, of which 252,704 are under the plough, 106,281 are in fallow, 23,389 are pasturel and, 148,364 are woods, 35,868 are waste, 56,414 are covered with lakes and estuaries, 22,267 are the beds of rivers and harbours, and the remainder roads, and the sites of cities, towns, and villages. The surface is very unequal, consisting of chains of hills running through the peninsula, some reaching the height of 1000 feet, with valleys between them of various extent.

The civil divisions are into five arrondissements, forty-three cantons, and 287 communes, inhabited by 452,450 persons. The inhabitants are a distinct race from the French, and mostly speak the old language of the Breyzards, the name by which they are distinguished. They are obstinate in their adherence to old and antipathy to new customs. Their clothing is little altered in the last thousand years, which in form and colour varies in each place, thus showing the dwelling of each person. There are whole communes in which no individuals are to be found who can read or write. They live either in scattered houses or small hamlets, and more than 25,000 houses are so wretched in appearance when seen, that they resemble the huts of savages. They are mostly hidden behind hedges and banks, and only visible by the smoke which issues from the doors, for they have neither chimneys nor windows. The cattle and the families live together in a state of disgusting filth. The females, who are commonly very ugly, are oppressed by their labour, and so contemptuously treated that they are not even suffered to eat with the men.

With all this they are said to be hospitable, upright, brave, and patriotic, and content with their barley bread, milk, and (but of late years) potatoes. The agriculture is in a backward state, and produces less corn than is required for the consumption; and since the population has increased, severe scarcity would be annually felt but for the introduction of potatoes, which are now extensively cultivated. The sheep, cows, and especially the horses, are diminutive; but the swine are fine and numerous.

The inhabitants of the towns in general are more like the other parts of the French nation. Those on the coast pursue the fisheries with success, especially that for sardinias. The only mines are those of lead, in which silver is found mixed with that metal. In two mines, at Poullalouen and Huelgoet, 900 workmen are employed, who raise yearly 600 tons of lead, and from it extract 26,000 ounces of silver.

In some parts, especially at Morlaix, there are some manufactories of linen, sail-cloth, twine, cordage, and paper. At that port also the surplus productions of the soil are exported to other portions of the kingdom, as well as to foreign parts.

FINLAND, a province formerly of Sweden, but at present under the dominion of Russia, of which it is called a stadtholdership. It extends from 19. 35. to 33. 1. east longitude, and from 59. 50. to 69. 55. north latitude; and, including Lappmark, extends over the vast space of 140,844 square miles, although the inhabitants in the year 1814 amounted to no more than 1,460,000. The country is generally hilly rather than mountainous, as none of the elevations exceed 3500 feet, and the highest are only in the north and in the west parts. In the east it is filled with sand hills, rocks, woods, marshes, lakes, and rivers; but between the hills are some spots, either cultivated, or affording natural pasture. On the sea shore, both in the Gulf of Bothnia and in that of Finland, the rocks and sands, and the small islands and shores, are so numerous as to render the navigation highly dangerous.

The climate, though varying with the degrees of latitude, is unfavourable to a great population, from the excessive cold of the long winter, and the excessive heat and aridity of the short summer. Yet, when under the Swedish government, Finland not only produced sufficient corn, chiefly rye, for its own consumption, but supplied a part of the demand of the metropolitan provinces. Of late the culture of potatoes has been extended. Finland produces hemp and flax; the former inferior in quality to the latter. The chief articles of export are the productions of the forest, which supply fuel to Stockholm, and masts and ship-timber to other countries. Considerable quantities of pot and pearl ashes, of pitch and tar, are also exported, and some salted fishes; but salt is a scarce commodity, and the want of it is felt by others as well as by the fishermen. The inhabitants being of different races, speak dialects of the Finnish, Lappish, and Swedish languages, whose origin being the same, are understood without much difficulty. The whole adhere to the Lutheran confession, except in some of the southern parts, where the Greek church has adherents among those of the Russian nation.

Since Russia possessed the country, the administration of that empire has been in part introduced, but with much deference to the ancient customs and laws of the inhabitants. The province is now divided into twelve circles.

FIRE, NATURE OF. See the article HEAT.

Wild FIRE, or *Greek-FIRE*, a kind of artificial or factitious fire, which burns even under water, and that with greater violence than out of it. It is composed of sulphur, naphtha, pitch, gum, and bitumen; and is only extinguishable by vinegar mixed with sand and urine, or by means of raw hides.

The motion or tendency of this fire is said to be contrary to that of natural fire, and always follows the direction in which it is thrown, whether it be downwards, sidewise, or otherwise. The French call it *Greek fire*, or *feu Grequois*, because it was first used by the Greeks, about the year 660; as is observed by Petavius, on the authority of Nicetas, Theophanes, Cedrenus, and others.

The inventor, according to the same authority, was an engineer of Heliopolis, in Syria, named Callinicus, who first applied it in the sea-fight in which Constantine Pogonates commanded against the Saracens, near Cyzicus, in the Hellespont; and with such effect, that he therewith burnt the whole fleet, in which were thirty thousand men. But others think it of much older date, and consider Marcus Gracchus as the inventor; an opinion which is supported by several passages both in the Greek and Roman writers, showing it to have been anciently used by both these nations in their wars. Constantine's successors used it on different occasions with equal advantage; and, what is remarkable, they were fortunate enough to keep the secret of the composition to themselves, so that in the year 960 no other nation was acquainted with the composition.

Hugh, king of Burgundy, having demanded ships of the Emperor Leo, for the siege of Fresne, desired likewise that they should be provided with the Greek fire.

Father Daniel gives a good description of the Greek fire, in his account of the siege of Damietta undertaken by St Louis. Every body, says that author, was astonished at the Greek fire, which the Turks then prepared, and the secret of which is now lost. They threw it out of a kind of mortar; and sometimes shot it with an odd sort of cross-bow, which was strongly bent by means of a handle or winch, and of much greater force than the mere arm. That thrown with the mortar sometimes appeared in the air of the size of a tun, with a long tail, and a noise like that of thunder. The French by degrees discovered the secret of extinguishing it, in which they several times succeeded.

Balls of FIRE, in *Meteorology*, are luminous bodies, which appear at a considerable height above the earth, shining occasionally with very great splendour, and sometimes leaving a luminous track behind them after they have disappeared. The larger ones in this hemisphere proceed generally from north to south with great velocity, frequently exploding into globes of smaller size, and sometimes vanishing with a report, sometimes without one. They are not unfrequently attended with a discharge of solid compounds of earthy and metallic matters, called meteoric stones, the descent of which, though stubbornly denied for a time, was finally established about the beginning of this century.

These luminous appearances no doubt constituted part of the ancient prodigies, blazing stars or comets, which last they sometimes resemble in being attended with a train; but they frequently appear with a round and well-defined disk. The first of these of which we have any accurate account, was observed by Dr Halley and some other philosophers at different places, in the year 1719. From the slight observations they could take of its course, the perpendicular height of this body was computed at about seventy miles above the surface of the earth. The height of others has also been computed, and found to vary from thirty-three to a hundred miles. The velocity at which they travel is estimated at from five to thirty-three miles in a second. The most remarkable of these on record appeared on the 18th of August 1783, about nine o'clock in the evening. It was seen to the northward of Zetland, and took a southerly direction for an immense space, being observed in the southern provinces of France, and, according to one account, in the ecclesiastical capital of Italy. During its course it frequently changed its shape; sometimes appearing in the form of one ball, sometimes of two or more, sometimes with a train, sometimes without one. It passed over Edinburgh nearly in its zenith, and had then the appearance of a well-defined round body, extremely luminous, and of a greenish colour, the light which it diffused on the ground giving likewise a greenish cast to objects. After passing the zenith it was attended by a train of considerable length, which continually augmented, and at last entirely obliterated the head, so that it looked like a wedge, flying with the obtuse end foremost. The motion was not apparently rapid, by reason of its great height; though in reality it must have moved with great velocity, on account of the immense space over which it travelled in a short time. In other places its appearance was very different. At Greenwich we are told that "two bright balls parallel to each other led the way, the diameter of which appeared to be about two feet; and were followed by an expulsion of eight others, not elliptical, seeming gradually to mutilate, for the last was small. Between each two balls a luminous serrated body extended, and at the last a blaze issued which terminated in a point. Minute particles dilated from the whole. The balls were tinted first by a pure bright light, then followed a tender yellow, mixed with azure, red, and green; which, with a coalition of bolder tints, and a reflection from the other balls, gave the most beautiful rotundity and variation of colours that the human eye could be charmed with. The sudden illumination of the atmosphere, and the form and singular transition of this bright luminary, tended much to make it awful; nevertheless, the amazing vivid appearance of the different balls, and other rich connective parts not very easy to delineate, gave an effect equal to the rainbow in the full zenith of its glory."

Dr Blagden, in a paper on the subject inserted in the seventy-fourth volume of the *Philosophical Transactions*, not only gave a particular account of this and other meteors of the kind, but offered several conjectures as to the probable causes of them. The first thing which occurred to philosophers on this subject was, that the meteors in question were burning bodies rising from the surface of the earth, and flying along the atmosphere with great rapidity. But this hypothesis was soon abandoned, on considering that there was no power known by which such bodies could either be raised to a sufficient height, or projected with the velocity of these meteors. The next hypothesis was, that they did not consist of one single body, but of a train of inflammable vapours, extending a vast way through the atmosphere, which being kindled at one end, displayed the luminous appearances in question by the fire running from one end of the train to the other. To this hypothesis, which was invented by Dr Halley, Dr Blagden objected that no just explanation was given of the nature of the vapours themselves, the manner in which they were raised up, or their regular arrangement in straight lines of such vast extent; or how they could be supposed to burn in such rarefied air. "Indeed," says he, "it is very difficult to conceive how vapours could be prevented, in those regions where there is in a manner no pressure, from spreading out on all sides in consequence of their natural elasticity, and instantly losing that degree of density which seems necessary for inflammation. Besides, it is to be expected, that such trains would sometimes take fire in the middle, and thus present the phenomenon of two meteors at the same time, receding from one another in a direct line."

For these and other reasons the hypothesis of Dr Halley was abandoned, and another substituted in its place. This was, that the meteors in question are permanent solid bodies, not rising from the earth, but revolving round it in very eccentric orbits, and thus in their perigeon moving with inconceivable rapidity. But this hypothesis is likewise objectionable. Another theory supposes that the meteors in question are a kind of bodies which take fire as soon as they come within the atmosphere of the earth. Sir Humphry Davy's discovery that the earths and alkalis are metallic oxides, affords some plausibility to this theory, especially in cases where the meteors are accompanied with the descent of solid bodies to the earth. It has been suggested that the bases of the earth may exist in the meteor in a metallic state, and that when the body arrives within the range of our atmosphere, the strong affinity which it is well known these metallic bases have for oxygen, causes them to unite and produce violent combustion. The origin of fire-balls has also been ascribed to the agency of electricity, and there seems little doubt that this is really the true way of accounting for them.

Falling or *shooting stars* are the same phenomena upon a smaller scale. They are to be seen at all seasons, but most frequently during the prevalence of the northern lights, and most commonly in the lower regions of the atmosphere. The cause of these phenomena, as of those of a more magnificent description, has been attributed to electricity. This theory, however, was objected to by Sir Humphry Davy; and his opinions on every subject are entitled to the highest deference, and to deliberate consideration. He conceived them to be attributable to falling stones. But the subject of meteoric stones, including fire-balls and other meteors, will be treated of under METEOROLOGY. It may also be mentioned, that Chladni, in his work on Fiery Meteors (Vienna, 1819), considers them as solid bodies, formed above the region of our atmosphere, and classes them with aerolites or meteoric stones. See METEOROLOGY.

FIRE-Engine. See STEAM-ENGINE.

FIRE-Escapes. See LIFE-PRESERVERS.

FIRE-Flies. See *Elator*, *Lampyris*, and *Fulgora*, in the Index to ENTOMOLOGY.

FIRE-Philosophers, or *Philosophi per Ignem*, a fanatical sect of philosophers who appeared towards the close of the sixteenth century, and made a figure in almost all the countries of Europe. The distinguishing tenet from which they derived this appellation was, that the intimate essences of natural things were only to be known by the trying efforts of fire, directed in a chemical process. They were also called Theosophists, from their declaring against human reason as a dangerous and deceitful guide, and representing a divine and supernatural illumination as the only means of arriving at truth; and Paracelsists, from Paracelsus, the eminent physician and chemist, who was the chief ornament of this extraordinary sect. It was patronized in England by Robert Flood or Fludd, who endeavoured to illustrate the philosophy of Paracelsus in a great number of treatises; in France it was zealously propagated by Rivier; in Denmark, by Severinus; in Germany, by Kunrath, an eminent physician of Dresden; and in other countries by ardent votaries, who assumed an air of piety and devotion, and proposed to themselves no other end than the advancement of the divine glory, and the restoration of peace and concord in a divided church. One of the most celebrated of these was Daniel Hoffman, professor of divinity in the university of Helmstadt, who, availing himself of some unguarded passages in the writings of Luther, maintained that philosophy was the mortal enemy of religion; that truth was divisible into two branches, the philosophical and theological; and that what was true in philosophy was false in theology. But Hoffman was afterwards obliged, by the interposition of Henry Julius, duke of Brunswick, to retract his invectives against philosophy, and to acknowledge in the most open manner the harmony of sound philosophy with genuine theology.

FIRE-Place. See FURNACE.

FIRE-Ship, or *Brulot*, a vessel filled with combustible materials, and fitted with grappling irons, to hook and set fire to hostile ships.

FIRKIN, an English measure of capacity for liquids, being the fourth part of the barrel, and containing eight gallons of ale, soap, or herrings, and nine gallons of beer, old measure. Imperial measure contains one sixtieth part less in the gallon. See WEIGHTS AND MEASURES.

FIRLOT, a dry measure used in Scotland. The wheat firlot contains $21\frac{1}{4}$ pints of that country, or about 2214 cubic inches; and the barley firlot, 31 standard pints, or 3232 cubic inches. Hence the Scotch wheat firlot exceeds the old English bushel by 33 cubic inches, and the imperial bushel by 4 cubic inches.

FIRMAMENT, in the ancient astronomy, the eighth heaven or sphere, in which the fixed stars were supposed to be placed. It is called the eighth, with respect to the seven heavens or spheres of the planets which it surrounds.

The firmament is supposed to have two motions; a diurnal motion, given to it by the *primum mobile*, from east to west, about the poles of the ecliptic; and another opposite motion from west to east; which it completes, according to Tycho, in 25,412 years; according to Ptolemy, in 36,000; and according to Copernicus, in 258,000; when the fixed stars return to the same precise points in which they were at the commencement of this grand revolution. This period is commonly called the Platonic or great year.

FIRMAN is a passport granted to travellers and others in the dominions of Turkey, and usually bearing the signet of the grand signior himself.

FIRMICUS, MATERNUS JULIUS, a Latin writer who flourished under the successors of Constantine. About the year 345 he composed a work entitled *De Erroribus Profanarum Religionum*, which he inscribed to Constantius and Constans, the sons of Constantine, and which is happily still extant, accompanied with the annotations of John Wouver. To Firmicus are also attributed eight books on astronomy, first printed by Aldus Manutius in 1501, and reprinted several times since; but as this work contains nothing relating to the true science of astronomy, and is filled with astrological calculations, after the manner of the Babylonians and Egyptians, Baronius doubts whether a good and pious Christian, as Firmicus is represented to have been, could have indulged in such profane and impious speculations. Cave, however, supposes that he might have written these books anterior to the date of his conversion from Paganism; a supposition not incompatible with the opinion of Baronius. Of the treatise on the *Errors of the Profane Religions*, the principal editions subsequent to that of Aldus are, one printed at Strasburg in 1562, another at Heidelberg in 1599, and a third at Paris in 1610, all in 8vo; but afterwards it was conjoined with Minucius Felix, and printed at Amsterdam in 1645, at Leyden in 1652, and again at Leyden by James Gronovius, in 1709, 8vo. It is likewise to be found in the *Bibliotheca Patrum*, and at the end of Cyprian, printed at Paris in 1666. (Dupin; Cave; Moreri; Fabricius, *Bibl. Lat.* and *Bibl. Lat. Med.*) (A.)

FIRST-BORN. (See PRIMOGENITURE.) In Scripture the term first-born is often used in a figurative sense, to signify that which is first, most excellent, or most distinguished in any thing. Thus it is said of Christ that he is "the first-born of every creature;" and in Revelation he is called "the first-begotten of the dead," that is, according to the commentators, begotten of the Father before any creature was produced, and the first who rose from the dead by his own power. "The first-born of the poor" signifies the most miserable of all the poor; and in Job, "the first-born of death" means the most terrible of all deaths.

FIRST Fruits (*primitiæ*), amongst the Hebrews, oblations to God of part of the fruits of the harvest, as an acknowledgment of his sovereign dominion. The first of these fruits was offered in the name of the whole nation, being either two loaves of bread, or a sheaf of barley which was thrashed in the court of the temple. Every private person was obliged to bring to the temple his first fruits, consisting of wheat, barley, grapes, figs, apricots, olives, and dates.

There was another kind of first fruits offered to God. When bread was kneaded in a family, a portion of it was set apart and given to the priest or Levite who dwelt in the place; but if there was no priest or Levite there, it was cast into the oven, and consumed by the fire. These offerings constituted a considerable part of the revenues of the Hebrew priesthood.

FIRST Fruits are frequently mentioned by ancient Christian writers as forming part of the church revenue. One of the councils of Carthage enjoins that they should consist only of grapes and corn; which shows that this was the practice of the African church.

FIRST Fruits, in the Church of England, are the profits of every spiritual benefice for the first year, according to the valuation thereof entered in the king's books.

FISC (*Fiscus*), in the *Civil Law*, the treasury of a prince or state, or that into which all things due to the public fall to be paid or delivered. The word is derived from the Greek φισκος, *a great basket*, used when they went to market. By the civil law, none but a sovereign prince has a right to have a fisc or public treasury. At Rome, under the emperors, the term *ærarium* was used for the revenues destined to support the charges of the empire;

the *fiscus* for those of the emperor's own family. The treasury, in fact, belonged to the people, and the *fiscus* to the prince. Hence the goods of condemned persons, if appropriated to the use of the public, were said *publicari;* if to the support of the emperor or prince, *confiscari.*

FISCAL, in the *Civil Law*, something relating to the pecuniary interest of the prince or people. The officers appointed for the management of the fisc were called *procuratores fisci*, and *advocati fisci;* and among the cases enumerated in the constitutions of the empire, where it was their business to plead, one is against those who have been condemned to pay a fine to the fisc on account of their litigiousness, or frivolous appeals to the courts of law.

FISH. See Ichthyology.

Fishes, in *Heraldry*, are the emblems of silence and watchfulness, and are borne upright, imbowed, extended, endorsed respecting each other, surmounting one another, fretted, and so on.

In blazoning fishes, those borne feeding should be deemed *devouring;* all fishes borne upright and having fins, should be blazoned *hauriant;* and those borne transverse the escutcheon, should be termed *naiant.*

Fish Ponds, excavations filled with water, and intended for the breeding or feeding of fish. In making a pond, its head should be at the lowest part of the ground, that the trench of the flood-gate or sluice, having a good fall, may not be too long in emptying. The best way of making the head secure is to drive in two or three rows of stakes about six feet long, at the distance of about four feet from each other, the whole length of the pond head, the first row of which should be rammed at least about four feet deep. If the bottom is false, the foundation may be laid with quicklime; which, when slaked, will render it as hard as a stone. Some place a layer of lime, and another of earth dug out of the pond, among the piles and stakes; and when these are well covered, drive in others as they see occasion, ramming the earth as before, till the pond head be of the height which is required.

The dam should be made sloping on each side, leaving a waste to carry off the superabundant water in times of floods or rains; and as to the depth of the pond, the deepest part need not exceed six feet, rising gradually in shoals towards the sides, for the fish to sun themselves, and lay their spawn. Gravelly and sandy bottoms, especially the latter, are best for breeding; and a fat soil with a white fat water, as the washings of hills, commons, streets, sinks, and the like, is best fitted for fattening all sorts of fish. For storing a pond, carp is to be preferred for its goodness, quick growth, and great increase, as breeding five or six times a year. A pond of an acre, if it be a feeding and not a breeding one, will every year feed two hundred carps of three years old, three hundred of two years old, and four hundred of a year old. Carps delight in ponds which have marl or clay bottoms, with plenty of weeds and grass, on which they feed in the hot months.

Ponds should be drained every three or four years, and the fish sorted. In breeding ones, the smaller fishes are to be taken out, to store other ponds withal; leaving a good stock of females, at least eight or nine years old, as they never breed before that age. In feeding-ponds, it is best to keep them pretty near of a size.

FISHER, John, Bishop of Rochester, was born at Beverley, in Yorkshire, in the year 1459, and educated in the collegiate church of that place. In 1484, he removed to Michael House in Cambridge, of which college he was elected master in the year 1495. Having applied himself to the study of divinity, he took orders; and becoming eminent as a divine, attracted the notice of Margaret, countess of Richmond, mother of Henry VII., who appointed him her chaplain and confessor. In 1501 he took the degree of doctor in divinity, and the same year was elected chancellor of the university. In the year following he was appointed Lady Margaret's first professor of divinity in Cambridge; and in 1504 he was consecrated bishop of Rochester, a see which he would never resign, though he was offered both Ely and Lincoln. It is generally known that the foundation of the two colleges of Christ-Church and St John's, Cambridge, was owing to Bishop Fisher's persuasion and influence with the Countess of Richmond; he not only formed the design, but superintended the execution, and was appointed by the statutes visitor for life after the death of Lady Margaret. On the promulgation of Luther's doctrine, the bishop was the first to enter the lists against him. Upon this occasion he exerted all his influence, and is generally supposed to have written the book on account of which Henry VIII. obtained the title of *Defender of the Faith.* Hitherto he had continued in favour with the king; but in 1527, having opposed his divorce, and denied his supremacy, the implacable Harry determined, and finally effected, his destruction. In 1533 the parliament found him guilty of misprision of treason, for concealing certain prophetic speeches of a fanatical impostor, Elizabeth Barton, otherwise called the Holy Maid of Kent, relative to the king's death, and condemned him, with five others, to suffer loss of goods and imprisonment during his majesty's pleasure; but he was subsequently released, upon paying a fine of L.300 for the king's use.

King Henry having now espoused Anne Boleyn, his obsequious parliament took the oath of allegiance proper for the occasion. But in this oath the Bishop of Rochester steadily refused to join, alleging that his conscience had not been convinced that the king's first marriage was against the law of God. For this refusal he was attainted by the parliament of 1534, and committed to the Tower, where he experienced cruel treatment, and would probably have died a natural death, had not the pope created him a cardinal. The king, having now determined on his destruction, sent Rich the solicitor-general, under the pretence of consulting the bishop upon a case of conscience, but really with a design to draw him into a conversation concerning the supremacy. The honest old bishop spoke his mind without suspicion or reserve; and an indictment and conviction of high treason were the consequence. He was beheaded at Tower Hill on the 22d of June 1535, in the seventy-seventh year of his age. Thus died this veteran prelate, who, notwithstanding his inflexible enmity to the Reformation, was undoubtedly a learned, pious, and honest man.

The Bishop of Rochester was the author of a number of works, of which the following is a list: 1. *Assertionum Martini Lutheri Confutatio;* 2. *Defensio Assertionis Henrici Octavi de Septem Sacramentis;* 3. *Epistola Responsaria Epistolæ Lutheri;* 4. *Sacerdotii Defensio contra Lutherum;* 5. *Pro Damnatione Lutheri;* 6. *De Veritate Corporis et Sanguinis Christi in Eucharistia, adversus Œcompoladium;* 7. *De Unica Magdalena;* 8. *Petrum fuisse Romæ;* 9. Several Sermons, amongst which was one preached at the funeral of Henry VII., and another at that of the Countess of Richmond; 10. His opinion of King Henry the Eighth's marriage, in a letter to T. Wolsey, printed at the end of the second volume of Collier's *Ecclesiastical History.* Most of the tracts above mentioned were collected and printed in one volume folio, at Wurtzburg in 1595. Fisher, as already stated, is supposed to have had a considerable share in the composition of Henry's book, entitled *Assertio septem Sacramentorum;* and in the Norfolk library of manuscripts belonging to the Royal Society there is an answer made by him to a book printed at London in 1530, concerning Henry's marriage with Queen Catherine.

FISHERIES.

We propose in the present article to take a general and extended view of this important branch of employment, and at the same time to give a sketch of the present state both of the home and foreign fisheries.

HOME FISHERIES.

Alleged neglect of by Great Britain.

The alleged neglect of the fisheries, on the part of Great Britain, has been the subject of unqualified censure from a very early period of her naval and maritime history; and reproaches have been dealt out with no sparing hand, not only for having disregarded those advantages so liberally bestowed by nature along the extensive coasts of her sea-girt islands, in supplying a wholesome and nutritious article of food for the sustenance of an abundant population, but also for suffering the nations of the Continent to resort to her very bays and harbours without molestation, and even purchasing from them that very property which she was either too ignorant or too indolent to procure by her own sagacity or industry, though neither of these required to be exerted in any extraordinary degree in the pursuit of this occupation. "The fishery," says Sir William Monson, "needs no discovery; the experience of our neighbours having found it out, and practised it since the year 1307, to their immeasurable wealth and our shame."

Contrasted with the attention of the Dutch.

Thus also Sir John Boroughs complains in his *Sovereignty of the British Seas*, that "it maketh much to the ignominy and shame of our English nation, that God and nature offering us so great a treasure, even at our own doors, we do, notwithstanding, neglect the benefit thereof, and, by paying money to strangers for fish of our own seas, impoverish ourselves to make them rich;" and as a contrast to our supposed indolence and indifference, he draws a lively picture of the bustle and activity which the herring fishery of Holland communicated to the various tradesmen and artificers, labourers, salters, packers, and others, and of the multitude of poor women and children to whom it afforded employment. In a little pamphlet entitled *England's Path to Wealth and Honour*, the whole alphabet in regular order is ingeniously brought to bear, in the shape of a dialogue between an Englishman and a Dutchman, on the trades and occupations connected with the herring fishery of Holland. The importance, indeed, of this branch of national industry in that country is pretty obvious from the following abstract of the population of the States-General taken in 1669.

Persons employed as fishermen, and in equipping fishermen with their ships, boats, tackle, conveying of salt, &c.	450,000
Persons employed in the navigation of ships in the foreign trade, wholly independent of the trade connected with the fisheries	250,000
Persons employed as manufacturers, shipwrights, handicraft trades, dealers in those manufactures	650,000
Persons employed in agriculture, inland fishing, daily labourers	200,000
Inhabitants in general not included in any of the above	650,000
Idle gentry without calling, statesmen, officers, soldiers, beggars, &c. supported by the labour of the rest	200,000
Making a total of	2400,000

From which it appears that the pensionary De Witt did not exaggerate when he stated that every fifth man earned his subsistence by the sea fishery; that Holland derived her main support from it; and that the herring fishery ought to be considered as the right arm of the republic. It is further asserted that, when in the zenith of her prosperity, not less than 3000 boats, of various kinds, were employed in the bays and islets of her own coasts; and that, in those of Great Britain, they had 800 vessels, from sixty to a hundred and fifty tons burden, occupied generally in the cod and ling fishery, besides others employed in carrying out salt to them, and returning with cured fish; that from Buchan-ness to the mouth of the Thames they had a fleet of 1600 busses actively engaged in the herring fishery, each of which might be said to give employment to three others in the importation of foreign salt, in carrying the salt to fishing ships and returning with cured fish, and in the exportation of that fish to a foreign market; thus making the total number of shipping engaged in and connected with the herring fishery alone to amount to 6400 vessels, calculated to give employment to 112,000 mariners and fishermen. By the same authority we are told that Holland, at that time, could boast of 10,000 sail of shipping and 168,000 mariners; "although the country itself affords them neither materials, nor victual, nor merchandise, to be accounted of towards their setting forth." Indeed the Dutch themselves made no scruple of avowing that the wealth, strength, and prosperity of the United Provinces were derived from the herring fishery; the importance of which was strongly marked by an observation in common use among them, that "the foundation of Amsterdam was laid on herring-bones."

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No wonder, then, that the example of the Dutch should be held forth as a reproach to England; and we find, accordingly, that it was so considered by some of the ablest writers of former times, as Sir Walter Raleigh, Sir William Monson, Sir William Petty, Sir Roger L'Estrange, and others. It would seem, however, to have altogether escaped these writers, that the situation and circumstances of the Dutch were entirely different from those in which the people of the British islands were placed. The provinces of Holland where the fisheries flourished had few or no resources but those which the waters afforded them, they grew no corn, they had no superabundance of food for the rearing of cattle, they had few or no manufactures; whereas Great Britain had all these, and abounded in most of them. The Dutch having, therefore, neither food nor raiment but what they must purchase from foreign nations, and the only article they had to offer in return being the products of the seas, it was necessary for them to expend their whole industry in availing themselves of those products, in order to exchange them for others of the land. It was not therefore from choice, but absolute necessity, that the Hollanders braved the dangers and submitted to the fatigues of the deep-sea fishery. It was their whole resource, and afforded them the only scope for turning their industry to profit; and it must be allowed that, by an extraordinary degree of patience and perseverance, and by long practice, they succeeded in bringing to a state of unrivalled perfection the mode of catching and the method of cure, which other nations, less experienced and less interested, had not arrived at; though it is now known and admitted that there is no great art or mystery in the craft, nothing that British fishermen could not then have, and, in point of fact, nothing which they have not of late years accomplished in as perfect a manner as the Dutch.

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But the case was different with regard to Great Britain. That country laboured under none of the disadvantages, Encou-rageme given t the fish ries.

and felt none of the necessities, which pressed upon Holland. Her capital was employed in foreign commerce, in the improvement of her agriculture, and in the introduction of some and the perfection of other branches of manufacture. The complaints, therefore, of the indolence of the British, of their buying fish from the Dutch rather than choosing to undergo the risk and fatigue of catching them, even on their own shores, will not perhaps, on due consideration, appear to be well founded. Their conduct may be ascribed rather to the very natural result of being able to employ their capital in more lucrative, more pleasing, and less precarious investments. It would be too much to expect that he who can buy a fish for half the money required to catch one, will quit his present employment and turn fisherman; or that he who can make a greater and more certain profit in commerce, agriculture, or manufactures, than by fishing, will divert his capital from the former to embark in the latter. The government had repeatedly held out encouragement for the pursuit of the fisheries, and aided the efforts of individuals in various ways to promote the success of a branch of national industry of so much importance to the national wealth and strength. Liberal subscriptions for this purpose have, at various times, been set on foot; privileges and immunities have been granted; villages have been built at the public expense, and ships and boats with all the necessary articles and tackle supplied; premiums have been conferred, bounties granted, duties exempted; the fishermen have been protected from the impress, and those who may have followed the occupation for seven years allowed to set up, and freely exercise any trade or profession in any town or place of Great Britain.

The failure, therefore, could not always have been owing to want of protection and encouragement, though it may, in some measure, be owing to the want of knowledge or circumspection in the way of administering it. Neither could it be ascribed to the want of funds. In 1580 a plan was matured for raising L.80,000 for establishing the British fishery. In 1615 the same sum was raised by a joint-stock company. In 1632 a royal fishing company was established by the sanction of King Charles I., who, in order to increase the demand, prohibited the importation of foreign fish, directed a supply to be furnished for his fleet, and ordered lent to be more strictly observed. In 1660 parliament granted a remission of the salt duties, and freed all the materials employed in the fisheries from customs and excise. In 1661 the national fishery met with very great encouragement under the auspices of Charles II. In 1677 this monarch incorporated the Duke of York and others into "The Company of the Royal Fishery of England;" but on this occasion the miserable capital was exhausted in the purchase and fitting out of a few busses, built in Holland, and manned with Dutchmen, which were seized by the French on the breaking out of the war. In 1713 it was proposed to raise L.180,000 on annuities, for the purpose of establishing a fishing company. In 1749, by the recommendation of George II. in his opening speech to parliament, and in consequence of a report of a committee of the House of Commons, the sum of L.500,000 was subscribed for carrying on the fisheries, under a corporation, by the name of "The Society of the Free British Fishery," of which the Prince of Wales was chosen governor. This society, patronized by men of the first rank in the kingdom, promised fair for a little time, but soon began to languish; nor was the large bounty of 56s. a ton able to prevent its total failure. The attention of parliament was again called to this great national object in 1786, when a new corporation was formed, under the name of "The British Society for Extending the Fisheries and Improving the Sea Coasts of the Kingdom," which has continued, with various modifications, to the present time; and, as we shall presently see, has of late years been in a flourishing and progressive state of improvement.

Present impediments to the progress of the fisheries exaggerated.

Thus, then, it is evident that we must seek for the real grounds of the general languishing state of the British fisheries in other causes than those which have usually been assigned by our ancestors; and though the complaint in modern times may have some foundation, which is almost exclusively levelled against the salt duties, and, after these were wholly removed, against the numerous checks and excise regulations, which are stated to be as grievous and discouraging as were the duties themselves; yet the impediments which these are alleged to throw in the way of the improving state of the fisheries have probably been much exaggerated. There can be no doubt that much benefit would be derived from a total repeal of all the acts relating to the duties and the regulations of salt; and yet, when the old writers stated their grievances, the article of salt is never once mentioned. In fact there were then neither duties nor restrictions on this article of universal use; and yet the fisheries did not flourish under the free and unlimited use of it.

The salt laws were supposed to operate strongly against the prosecution of the fisheries, and this was stated as one of the reasons which produced their repeal; but they scarcely affected those fisheries which were established and conducted on a grand scale. What then, it may be asked, is the real cause of our fisheries not being carried on to a greater extent, at a time when population is so rapidly increasing, and work not to be found for multitudes of the labouring classes of the community? It certainly is not that the government is indifferent or insensible to the political importance of the fisheries. It has not only at different times held out such encouragements as were deemed conducive to the end in view, but shown itself so jealous of the interference of our neighbours as to attempt to establish an appropriate and exclusive fishery in all the seas surrounding our coasts. Thus James I. in 1600 issued a proclamation prohibiting all persons, of what nation or quality soever, not being natural born subjects, from fishing upon any of the coasts and seas of Great Britain and Ireland, and the isles adjacent, without first obtaining licenses from the king. But this, as well as the repetition of the prohibition by Charles I. in 1636, was utterly disregarded by the continental powers. To enforce this measure, the Duke of Northumberland, as admiral of the fleet, was sent into the North Sea to compel the Dutch fishermen to take licenses, and pay for the same; but the ambassador of the States-General in England remonstrated against so unprecedented a proceeding, and disavowed the acts of their fishermen.

The attempt to set up a limited fishery, and to prescribe boundaries to the prohibited grounds, met with no better success; but they showed at least a desire to prevent the advantages derivable from this element from falling into the hands of others. It is probable, however, that these claims were set up with the view rather of maintaining the title of the sovereignty of the seas, than from any contemplation of the national advantages derivable from the encouragement of the fisheries; and more especially for the purpose of preventing any encroachments on the part of the Dutch and French.

This, however, has been found to be impossible. The Dutch continue to fish even into the mouths of the Thames, and the French insist on their right to fish within a mile of the English coast, whilst they also claim the right of excluding our fishermen within a league of their own shores, and in some places three leagues; and it is contended by jurists, that as the fisheries on the sea are common to all mankind, no fixed laws can be made by any nation to the exclusion of any other, and that whatever rights or restrictions now exist, are sanctioned by prescriptive usage, and can only be altered by treaties or conventions between the parties who may mutually agree to a change.

Real cause of the backward state of the fisheries.

The simple fact we take to be this; that the success of the fisheries, like that of every other speculation, must depend mainly on the two great hinges on which all commercial enterprises turn, viz. supply and demand; where these exist to any great extent, and without any material fluctuation, the success of a fishery establishment cannot be doubtful. If, however, the supply be not equal to the demand, the article will be in danger of falling into the hands of monopolists, whose common practice is to add to the scarcity in order to enhance the price. By thus contracting the supply within its natural limits, they not only raise the price, but reduce the demand. On the contrary, where the supply exceeds the demand, the market becomes glutted, the prices are too low to afford a suitable return for the expenditure, and the adventurers withdraw their capital, and turn it into some more profitable channel. But a certain and steady demand creates competition, and regulates the supply according to the wants of the consumer, at a fair and reasonable price.

Want of steady demand.

It is the want, we conceive, of this steady and constant demand, and not of supply, which has at all times operated to the discouragement of the British fisheries. That the supply of fish is most abundant, and indeed inexhaustible, on the coasts of Great Britain, has never been called in question. "The coasts of Great Britain," says Sir John Boroughs, "doe yield such a continued sea-harvest of gain and benefit to all those that with diligence doe labour in the same, that no time or season in the yeare passeth away without some apparent meanes of profitable employment, especially to such as apply themselves to fishing; which from the beginning of the yeare unto the latter end, continueth upon some part or other upon our coastes, and these in such infinite shoales and multitudes of fishes are offered to the takers, as may justly move admiration, not only to strangers, but to those that daily bee employed amongst them." That this harvest, ripe for gathering at all seasons of the year, without the labour of tillage, without expense of seed or manure, without the payment of rent or taxes, is inexhaustible, the extraordinary fecundity of the most valuable species of fish would alone afford abundant proof. To enumerate the thousands and even millions of eggs which are impregnated in the herring, the cod, the ling, and indeed in almost the whole of the esculent fish, would give but an inadequate idea of the prodigious multitudes in which they flock to our shores; the shoals themselves must be seen, to convey to the mind any just notion of their aggregate mass. The herring, for instance, makes its appearance in shoals, the dimensions of which are measured by leagues and miles, moving steadily along in close array, and in columns of such depth from the surface downwards, as to have obtained the name amongst the northern nations of *herring mountains*. These columns advance yearly from the northern seas, early in the spring, with undiminished numbers, though preyed upon by a multitude of enemies, as well from the shore, as in their native element and in the air. Wherever their vast columns proceed, if unmolested by man, they have to sustain constantly the attacks of the grampus, the porpoise, the shark, cod-fish, and even haddocks; and if they approach the surface, they are seized by the innumerable flocks of sea-gulls, gannets, and other aquatic fowls, which hover along their line of march. Where the spawn of the herring is usually deposited, naturalists do not seem to be agreed; but as young herring have not been caught, either with the old ones, or within the limits of the fishery, and as the shoals invariably proceed from the northward, making their first appearance about the Zetland Islands in the month of April, it has generally been thought that their winter habitation is within the Arctic circle, under those vast fields of ice which cover the Northern Ocean, where they fatten on the swarms of shrimps and other marine insects which abound in those seas, and which afford also the principal food of the whale. Here it is supposed they deposit their spawn, and, on the return of the sun toward the northern hemisphere, again rush forth in those multitudinous hosts which exceed the power of the imagination to conceive.

The pilchard, which is a species of the same genus as the herring, is also a migratory fish, but makes its appearance from the southward, in vast shoals, inferior only to those of the herring; which is also the case with the mackerel, both being of equal or greater fecundity with the herring, and liable to the attacks of the same enemy. The salmon is equally irregular in its visits to the coasts of Great Britain and Ireland, and approaches the mouths of our rivers in shoals, which they ascend to considerable distances, surmounting every obstacle in order to find a safe and convenient spot where to deposit their innumerable eggs. The various kinds of white fish, as turbot, sole, plaice, whitings, and haddocks, are plentifully dispersed throughout various parts of the British seas, affording an inexhaustible supply of fresh fish for home consumption during the whole year, without the least apprehension of such supply being exhausted or diminished. On the eastern shores of Great Britain, and on the rocky coasts of the Orkney and Zetland Islands, are plenty of lobsters, which would more than supply the market of the metropolis with this article of luxury, as the south-eastern and southern coasts do the oyster with its nutritious food for eight months in the year.

Use sh scarce know the ir rior.

In spite, however, of this abundant supply of wholesome, palatable, and nutritious food, yielded by the surrounding seas of Great Britain, every acre of which is infinitely more productive than the same quantity of the richest land; notwithstanding that these salt water fields are perpetually "white to harvest," it is a remarkable fact, that in the inland and middle counties of England, the labouring classes scarcely know the taste of fish, which, of late years, has become a scarce article, even in most of the maritime counties. Formerly salmon, whilst in season, was the common food of all ranks in the northern counties bordering on the sea, and in most parts of Wales, and what could not be used fresh was salted for winter consumption; there was scarcely a family in the neighbourhood of a sea-port or salmon fishery that did not lay up a supply of pickled salmon for the winter. In the progress of luxury, well-boats were invented to convey the fish fresh to the London market, yet these were not sufficiently numerous to carry off the whole supply. The next contrivance was that of packing them up in ice, by which they could be kept fresh for a length of time, and conveyed either by land or water to the metropolis; since which the local markets have nearly been left without a supply, even for the few families who can afford to pay an extravagant price for the article. That price in London was for a long time greatly enhanced, by the trade being almost exclusively in the hands of monopolists, who had it at all times in their power to create an uncertainty in the supply, and consequently a fluctuation in the price, both of which are detrimental to an augmented demand; but that monopoly has been recently broken down.

That a narrow confined corner, at the very extremity of the metropolis, should have been allowed for such a length of time to exercise the privilege of absorbing all the fish brought within the radius of seven miles round its vortex, but ill accorded with the boasted good sense of these enlightened times. It needs scarcely be mentioned that Billingsgate was this favoured spot; holding by charter an injurious and hateful privilege, which, as Sir Thomas Bernard justly observes, "in the greatest and most populous city in the world, restricts the sale of an article of life to a small and inconvenient market, and has exclusively placed the monopoly of fish in the hands of a few interested salesmen." The establishment of that splendid and most commodious market, the Hungerford, has put an end to that injurious monopoly, and consequently reduced the prices and increased the quantity of this species of food for the use of the metropolis.

Obser tions o bounti

The encouragement given by the government in the shape of bounties appears to have contributed but little to the success of the fisheries. If a branch of trade once fairly established will not support itself without being bolstered up by bounties, it never can be worth carrying on. Bounties should only be continued for a definite time, and decreased gradually. Those on the fisheries should be given on the quantity procured, and the quality of those cured, and not on the instrument of their production; on the fish, and not on the vessel. It was proved by a committee of the House of Commons, in 1785, that the herring fishery absolutely cost little short of L.20,000 annually, which, on an average of ten years, was equal to L.75 per cent. on the value of all the fish that had been taken by the vessels on which it was paid. Adam Smith has justly observed, that a tonnage-bounty proportioned to the burden of the ship, and not to her diligence and success in the fishery, is not the best stimulus to exertion; it was an encouragement for fitting out ships to catch, not the fish, but the bounty; or to induce rash adventurers to engage in concerns which they did not understand, and cause them to lose, by their ignorance, more than was gained by the liberality of government. The carelessness of such persons, and the ignorance of those employed by them in curing and packing the fish, not only robbed the public purse, but destroyed the character of the article in the foreign market; where, if saleable at all, it fetched only an inferior price, whilst the skill and attention of the Dutch secured for their fish that preference to which they were justly entitled. The change of the bounty, however, from the tonnage to the quantity and the quality of the fish caught and cured, with the regulations adopted by the acts of 48th and 55th Geo. III. have had the good effect of raising the character, and consequently increasing the demand, for British fish in the foreign markets, where the herrings in particular are now held in equal estimation with those of the Dutch. The bounty, granted by the act 48 Geo. III. c. 110, is 2s. per barrel on all herrings branded by the proper officers, and 4s. a barrel granted by the act 55 Geo. III. c. 94, and is so considerable that at this time it amounts to a sum not less than L.30,000 a year.

Experi ments showin the pos bility o extendi the de mand.

It would appear, however, that all which is now wanting for the encouragement and extension of the British fisheries, is a constant, steady, and increased demand in the home and foreign markets. An experiment made by Mr Hale, one of the members of the committee for the relief of the manufacturing poor, proves decisively how easy it would be to introduce the general use of fish in the metropolis. He agreed with some fishermen to take from ten to twenty thousand mackerel a day, at a price not exceeding 10s. the hundred of six score, or at a penny a piece, a price at which the fishermen said they could afford to supply the London market to any extent, provided they were sure of a regular sale. On the 15th of June 1812, upwards of 17,000 mackerel were sent to Spitalfields, and sold at the original cost of a penny a piece, to which place women were employed to carry them from Billingsgate until eleven o'clock at night. They were purchased with great avidity, and vast numbers continued to pour into Billingsgate. They were sent to other parts of the town, and sold to the poor at the same rate; and it is stated that "the supply increased to so great a degree that 500,000 mackerel arrived and were sold in one day." The whole cost of this experiment, for the distribution of fresh and sweet mackerel at a penny a piece, was L.55. 10s. expended chiefly in the carriage from Billingsgate. In like manner, it is estimated that herrings might be supplied in any quantity at one halfpenny a piece, and cod, haddocks, whitings, flounders, &c. proportionally cheap, provided a steady demand was created, as it is presumed there would be, by the establishment of several regular markets in different parts of the metropolis.

Another experiment of the committee shows how easily a demand for salted or corned fish might be created in the inland counties. They contracted for 200 tons of corned cod, caught and cured on our own coast, and also for 400,000 corned herrings. The former was supplied to the distressed manufacturers of Sheffield at twopence halfpenny a pound, and the latter at the rate of two for three halfpence. Here, as well as in other parts of the country, the poor, it is stated, received the fish distributed among them at low prices with the liveliest gratitude; and one gentleman in Worcestershire states that "the herrings, in particular, have proved a bonus to the poor of the most essential benefit. We sold them," he says, "at a very low and reasonable rate, on account of the extreme indigence of the purchasers; and they have produced L.40 (profit), which, after the expense of carriage is paid, will be laid out in employing the poor in repairing the roads."

It deserves to be mentioned, as an instance of the certainty of a supply to answer the demand, that, when the Association was formed in 1812, the North Sea and Iceland fishery had for some time entirely ceased; but, on the committee offering the fishermen L.18 a ton for all the fish they should catch and cure, they supplied, in the first instance, 100 tons of dry-salted, and fifty tons of fresh cod; in the second, 200 tons of dry-salted, and 400 tons of fresh; in the third, 600 tons of dry-salted, and 300 tons of fresh; in all 1350 tons of fish were taken and brought to market in consequence of this offer, not a fish of which would otherwise have been caught.

The obvious policy, then, to be pursued for extending the British fisheries, is by creating an extended and constant demand. In the foreign markets this can only be done by the care and attention bestowed in curing the fish, so that, in point of quality, it may compete with those of the Dutch and other nations of the continent; a point which we have just now happily attained; but in the supply for home consumption every thing almost yet remains to be done. The Fish Association have, however, clearly shown the way of proceeding to obtain this desirable end; they have proved that, not only in the metropolis, but in the interior of the country, the poor have none of those prejudices which were ascribed to them, against the use of fish, when it is fresh and sweet, and when they are able to procure it at a moderate price. A free circulation, by means of markets established in the metropolis and at all the fishing ports, might effect this to a certain degree; but, in addition to these, some artificial expedients might be advisable, for a time at least, to raise and keep steady the demand. It is much to be regretted that Queen Elizabeth, who was well aware of the importance of the fisheries in a political as well as economical point of view, did not, in regulating the church ritual, ordain two days in every week to be set apart by Protestants as fish days, which would have created a steady and permanent demand for fresh and salted fish in every part of the United Kingdom. Such an ordinance might, in her reign, have been enforced, and long habit would have reconciled people to the observance of those days in our times; but it would be in vain to attempt the introduction of any such custom in the present refractory generation. There seems, however, to be no good grounds of objection to those who are maintained at the public expense being fed twice a week with a wholesome meal of fish. It is neither just nor politic that, whilst the poor labouring man, after toiling the whole week, can scarcely procure a little brown bread and a few potatoes for his wife and children, the indolent pauper should feed on the best white bread and choice butchers' meat. Supposing the number of paupers receiving parish relief, of convicts in the hulks, criminals in the jails, and, in short, all those who are fed at the public expense, to amount only to 1,000,000; and that to each was served out, twice a week, a sufficient allowance of good fresh fish, corned cod, or salted herrings, according to the season of the year and the situation of the parties, which could be amply provided for the value of three pence a head, the annual demand for fish, from this source alone, would amount to the sum of L.1,300,000. The voluntary consumption of the labouring poor would be at least equal, could an adequate supply be obtained at a cheap rate; and that it might will readily be inferred, when it is stated that, in the herring season, these fish may, on an average, be purchased at the stations for sixpence a hundred, whilst the salt required to cure them costs about one penny. Supposing the whole expense of a hundred to be one shilling, and one shilling more for land carriage to the farthest point in the interior, and allowing the retailer a profit of 100 per cent., a good salted herring might still be purchased for one halfpenny, and two herrings, with a few potatoes, would furnish a wholesome palatable meal. Salted or corned cod would be supplied at an almost equally cheap rate; and thus the quantity of food for the subsistence of man would be greatly increased, the fisheries encouraged, the consumption of butchers' meat lessened, and more pasturage converted into corn-lands, by which the enormous sums of money which are annually sent out of the country for the purchase of foreign corn would be employed at home. At present we have to trust for a supply of this "staff of life" to a miraculous plenty or a ruinous importation.

Political importance of the fisheries.

It would be superfluous to dwell on the political, economical, and commercial importance of encouraging and improving the fisheries, to an insular empire like ours. We shall only observe, that, by their augmenting the quantity of food, there would necessarily result a reduction in the prices of all the necessaries of life; the condition of the labouring poor, the artificers, and trades-people, would as necessarily be improved; they would not only be the means of rearing and supporting a bold and hardy race of men for the defence of the sea-coast, but also of creating a nursery of excellent seamen for the navy in time of war, and of giving them employment when peace may render their further services unnecessary. If the fisheries flourished to that extent to which they appear to be capable, every seaport, town, and little village on the coasts, or on the banks of the creeks and inlets, would become a nursery of seamen. It was thus in Holland, where the national and natural advantages were very inferior to those of Great Britain; for it is well observed, in the *Report of the Downs Society*, that Holland produces neither timber, nor iron, nor salt, all of which are essential to fisheries, and all the natural produce of Great Britain; that Holland has no herrings upon her own coast, whilst the coasts of our island abound with them and other fish, at different if not at all seasons of the year, so that there are few if any months in which shoals of this fish in particular are not found on some part of our shores; and lastly, that her population is under 3,000,000, whilst ours amounts to about 18,000,000, giving to our fishermen six times the consumption of a home market that the Dutch can command.

Though the occupation of a fisherman is dangerous, laborious, and precarious, yet it does not appear that the want of sufficient hands has at any time retarded the progress of the fisheries. At this moment about 20,000 seamen, receiving pensions of from L.7 to L.20 and upwards, according to their wounds, infirmities, and length of service, are located for the most part along the sea-coasts of the united empire, all of whom, not otherwise employed in the coal and coasting trade, would readily add to the little pittance they receive from a grateful public, by being employed on an element so congenial to their habits.

The report of the committee which sat in the year 1833 to inquire into the present state of the Channel fisheries, ascribes the decline of these fisheries to other causes than the want of demand. They report that they find the British Channel fisheries to be generally in a very depressed and declining state; that they appear to have been gradually sinking since the peace in 1815, and more rapidly during the last eight or ten years; that the capital employed does not yield a profitable return; and that the number of vessels and boats, as well as of men and boys employed, is much diminished: and they ascribe the principal causes that have tended to produce this depression, *first*, to the extensive interference and aggressions of the French fishermen on the coasts of Kent and Sussex; *secondly*, to the large quantity of foreign-caught fish illegally imported and sold in the London market; and, *thirdly*, to the great decrease and comparative scarcity of fish in the Channel.

1. With regard to the interference of the French fishermen, they have undoubtedly, as we have observed, an advantage over ours, by fishing within half a league of the shores of Kent and Sussex, and frequently much nearer; but if it be true, as is stated, that they have now between 200 and 300 sail out of Boulogne alone, being more numerous and larger than those of our countrymen, manned with double or treble the number of men, and carrying nets and fishing-gear of a much larger and heavier description, what can possibly occasion this great difference in favour of the French over us, but the very great demand for fish in the one country and the want of it in the other. It is the great demand alone that affords them capital to send out more boats, and of a larger size, with more men in them, than our fishermen, for want of demand, can afford to do. In fact, fish in a fresh, or salted or dried state, may be said to be in universal demand throughout France, whilst in England the supply is almost wholly limited to the capital, and a few large towns at no great distance from the sea-coast. The middling and lower orders in England, generally speaking, have no great relish for fish; they give the preference ten times over to bacon, and every species of butchers' meat. The herring and mackerel fisheries are stated to have been nearly abandoned, whilst the French continue on our coasts during the whole of the season of these fisheries, making a constant practice of selling their cargoes of fish at sea, and shipping them into carrier boats from the Thames and other ports, and into boats which board them in the bay of Dover, for the supply of the London market. This practice requires but small capital and little outlay. Such an intercourse may also have for its object the more profitable occupation of smuggling, as well as trafficking for fish. A further grievance, and one that certainly ought to be prevented, is, that at other seasons of the year the French come every morning from Boulogne and other places, into the English bays, and there drag with nets for bait in the shallow waters, close upon the shore, taking and destroying, in immense quantities, the young and unsizeable fish; and this is done at those periods of the year when they are not permitted to fish in the bays upon their own coasts; a practice which tends materially to diminish the quantity of grown fish on our coasts.

The suggestion of the committee, that, in order to remedy the grievances at present sustained by the English fishermen, foreigners should be prevented, at all seasons of the year, from fishing within one league, or such other distance, of the English coast, as by the law or usage of nations is considered to belong exclusively to this country—this would undoubtedly be most desirable if it could be effected; but we have conceded this point, and ancient *usage* is unfortunately against us, and the *law* cannot remedy it; the grievance can only be removed by mutual agreement. Measures, however, it is presumed, might be taken for the better preservation of the spawn and brood of fish in the bays and shallow waters upon our coast, which is of the utmost importance.

2. The importation of foreign-caught fish is prohibited by various acts of parliament, under heavy penalties and forfeiture, imposed on the parties, both foreigners and British subjects, who may be implicated in such a transaction. The kinds of fish exempted from prohibition are, turbots and lobsters, eels, stock-fish, anchovies, sturgeon, botargo, and cavear; these may all be, and are, legally imported,—turbots and eels generally by the Dutch, and almost all the lobsters from the coast of Norway. The committee however report, that, notwithstanding the prohibition and penalties, it appears in evidence that about one third of the fish supplied to the London market is procured from foreigners, including, however, in that estimate, the turbots, eels, and lobsters. It is further stated that the violation of the acts of parliament has of late years been practised openly, and without interruption on the part of the government or officers of his majesty's customs, arising probably, as the committee think, from some misapprehension of the provisions of the statutes. The practice, it appears, prevails chiefly off the mouth of the Thames, and upon the coasts of Kent and Sussex, and it operates most injuriously during the mackerel and herring seasons.

Our fishermen complain that they are much injured by the continued permission given to foreigners to import turbots free of duty; and it is stated in evidence, that if relief were afforded in this respect to the English fishermen, the markets of this country would still be adequately supplied with this valued species of fish, without increased prices; and that the alteration of the law, in this respect, would tend very materially to revive the fisheries connected with the coasts of Norfolk and Essex, and also with those of Kent and Sussex, and be of great value to our fisheries in general. There do not seem to be any political grounds for opposing such an enactment, as the English fishermen are not allowed to import any description of fish into France or Holland. Why should not our fishermen, when driven by stress of weather or for repairs into a French or Dutch port, be permitted to sell a sufficient portion of their fish to provide themselves with necessaries for their support, whilst this indulgence is granted to those of France and Holland in the ports of England?

3. The scarcity of fish in the Channel, with the exception of mackerel and herring, which are fish of passage, is said to have increased during the last fifteen or twenty years, occasioned by the great destruction of the spawn and brood of fish consequent on the non-observance of the laws which at present exist for their preservation. By the statute 3 James I. "for the better preservation of sea-fish," it is enacted, that "every person who shall fish in any haven, harbour, or creek, or within five miles of the mouth of any haven, harbour, or creek, with any draw-net or drag-net under three inches mesh, or with any net with canvass or other engine or device, by which the spawn, fry, or brood of sea-fish may be destroyed, shall forfeit such net, and also ten shillings." By 14 Charles II. "for regulating the pilchard fishery," from the 1st June to 30th November no person shall take fish in the high sea, or in any bay, port, creek, or coast of Cornwall or Devon, with any drift-net, trammel, or stream-net, or other nets of that sort, unless at the distance of one league and a half from the shore," under penalty of forfeiting the nets or value, and one month's imprisonment of the offender. The 1st Geo. I. enacts "that the meshes of nets used at sea upon the coast of England shall not be less than three inches and a half from knot to knot," under penalty of forfeiture of nets, and of L.20, with power of imprisoning the offender. The 33d Geo. II. provides "that no person shall kill or destroy, or knowingly have in his or her possession, either on the water or on shore, or shall bring to shore, or offer for sale or exchange, any spawn, fry, or brood of fish, or any unsizeable fish, or fish out of season," under the penalty of twenty shillings, and forfeiture of the baskets or other packages containing them.

These salutary statutes seem to have been neglected, and, in the opinion of the committee, ought to be revised, and the provisions extended; and that conservators or overseers should be appointed for the purpose of enforcing the act. The French take care to protect their bays and breeding-grounds from the 15th April to the 1st September, the intermediate months being the spawning or breeding season of the fish, when the young brood have not become of a sufficient size or strength to take refuge in deeper waters. It is stated in evidence, that in the year 1816 the Trowl fishermen on the coast of Devon, acting under the advice of the present Lord Vernon, tried the experiment by mutual consent, of preserving their breeding-grounds undisturbed from the 1st of July to the 20th of September in that year, the consequence of which was a greater abundance of fish in the ensuing season than had ever before been known upon that coast; and the fishermen were desirous that the restraint which they had thus voluntarily imposed upon their fishing should in future be enforced by law. Accordingly, in 1819 a bill was brought into the house, "to prevent the destruction of the brood and spawn of fish," which, however, was thrown out on the third reading; but in the year 1822 the same bill was again brought in and passed the Commons, but was lost in the Lords; since which no further attention appears to have been paid to the subject, and thus the evils complained of have continued unredressed, and, as it appears, are increasing.

The stow-boat fishery, or catching of sprats for manure, which prevails principally upon the Kentish, Norfolk, and Essex coasts, is highly injurious to the spawn and brood of fish, the nets used being so very fine as to enclose not only sprats, but the spawn and young breed of all other kinds of fish. The demand for this species of manure is said to be so extensive, that there are at this time from 400 to 500 boats engaged in stow-boating on the Kentish coast only, each remaining out till it has obtained a full cargo of dead fish for the purpose of manuring the land. The legislature ought certainly to put a stop to this most injurious practice, or at least confine it within specific limits both as to time and space.

It is stated that the herring and pilchard fisheries have declined considerably, not so much from the competition of French fishermen, as from the heavy duty levied at Naples of sixteen shillings a barrel, which amounts nearly to a prohibition; the pilchard fishery also suffers from the same cause. It appears also that the clergyman demands tithe to the amount of between two and three pounds per annum for each herring or mackerel boat, which appears not to be more than about one-eightieth part, after deducting the boat's expenses.

It is suggested that it would afford some small encouragement to the fisheries, by increasing the inland consumption, if the fish-carts were allowed to pass the turnpike gates free of tolls. This exemption, if granted, would particularly relieve the fisheries at Yarmouth, Harwich, Dover, Folkestone, and Hastings, and increase their supply of fresh fish, particularly of mackerel, to the London market. London, however, is the best supplied market for fish, perhaps, in the kingdom, and it does not appear that any monopoly or injurious regulations now exist, either in the mode of supplying the market or in the sale of fish.

It may be curious to see the weekly supply of different kinds of fresh fish for the London market, that is to say, for six days from the 19th to the 24th of June inclusive:—

Salmon........................	253½	boxes.
Turbot........................	3,153	individuals.
Lobsters........................	131,000	do.
Mackerel........................	131,700	do.
Whitings........................	31,175	do.
Soles........................	164	bushels.
Maids and plaice............	1,045	do.

Besides fresh cod-fish, skate, haddock, and other fish in smaller quantities.

Actual progress of the British herring fishery.

With all the impediments to an extended use of fish in the home market, and notwithstanding the established character which the Dutch fish have always borne among foreign nations, it is consoling to find that the herring fishery generally has been in a progressive state of improvement. Since the act of 48 Geo. III. appointing commissioners, separate and distinct from the customs and excise, to superintend the distribution of bounties, stationing of officers versed in the trade of the herring fishery, persons who had experimentally and practically followed that fishery as a trade, but who are excluded from all interest or participation in the trade, the herring fishery has become with us, as it was with the Dutch, an object of national concern; the good effects of which are most sensibly felt in every part of the coast where it has regularly been established, by the labour it provides, the demand it creates for a variety of articles required by it, and the money it throws into circulation. By this act, an annual report by the commissioners, of their proceedings, ending the 5th April, is required to be presented to parliament each session; containing the details of the fishery of the preceding year, together with such observations and suggestions as may have occurred, or been communicated, to the commissioners, in the interval between the reports. In the report of the year ending 1814, they had stated, "that the superior value of herrings branded by the officers of the fishery, in point of quality, weight, and measure, was becoming every year more generally acknowledged, even in markets where till of late gutted herrings were not much prized; and this they ascribe to their refusal of every application for allowing bounty on barrels out of the full size of thirty-two gallons, and to their having directed prosecutions against the proprietors of such herrings as had been seized, for being presented for bounty in undersized barrels; and that, with other precautions respecting the proper cure of the herrings, the desired effect had been produced, of raising the character of British herrings in the foreign market." In their report of 1816, they state that they have had their attention turned to different matters calculated to improve the cure of herrings, and to raise the character of the British fishery in foreign parts; that a communication, made to them by a mercantile house of respectability, on the subject of increasing the exportation of herrings to the Continent of Europe, had been printed, and distributed among the curers throughout the kingdom; that regulations had been adopted for improving the construction of barrels intended for bounty; that the boats of the fishermen had been properly fitted up for the reception of herrings; that bounty had been refused on all barrels not full of pickle; and that the strictest orders had been given to the officers of the fishery, to apply the official brand in no case, unless both herrings and casks were in every respect such as would do credit to the establishment. In the year 1817, the commissioners point out in their report the great increase which had taken place in the exportation of British herrings to the Continent of Europe, in consequence of the communication made to and the regulations adopted by them, as contained in the preceding report; and, in the year 1818, they observe that they had received a memorial on the subject from Hamburg, signed by a number of herring merchants of that port, bearing testimony to the improvement which had taken place in the quality of British herrings, and pointing out the means of raising their character still higher. This memorial the commissioners likewise caused to be printed and distributed amongst the curers, which they accompanied with such additional observations as they conceived to be necessary, and which they state to have produced the most salutary effects. They conclude their statement with the gratifying intelligence, that the character of the British fishery is rising both at home and abroad; for that, whilst the quantity of herrings cured *gutted* is annually increasing, the quantity cured *ungutted* is every year diminishing; that, great as the amount of the fishery had been in the course of that year, the demand had fully kept pace with it; and that, at the end of the season, few herrings remained unsold in the hands of the curers. They further report, that whilst the exportation to the Continent of Europe had nearly equalled that of the preceding year, and the exportation to the West Indies and Ireland had increased, a new market had opened in the East Indies, to which different shipments of herrings had been made, by way of experiment, both from Greenock and London; that, from the former of these places, upwards of 1300 firkins were exported to Calcutta, all of which, they understood, were purchased by Europeans there at 20s. to 25s. per firkin; and that it was the intention of the exporter, in consequence of this encouragement, to ship a larger quantity next season; so that the commissioners trust that India will soon become a permanent and valuable market for the consumption of British herrings. The report thus concludes: "It is impossible to state, within the compass of this report, the advantages resulting to the community from the prosperity of the herring fishery; but the commissioners think it their duty briefly to mention that the effects thereof are felt in almost every part of the kingdom. The fishermen have, in many cases, been enabled, by the produce of their industry, to replace the small boats formerly used, by new boats of much larger dimensions, and to provide themselves with fishing materials of superior value. The number of boats and of fishermen has been greatly increased; while, by the general introduction of the practice of *gutting*, a valuable source of employment has been opened to thousands of poor people, who now annually resort to the coast during the continuance of the fishing season, and there earn a decent livelihood in the operations of gutting and packing. New dwelling-houses and buildings, on a superior construction, for the curing and storing of the herrings, are erecting at almost every station along the coast; while the demand for home wood for the manufacture of barrels affords a source of profit and employment to numbers of people in the most inland parts of the country."

The following report for the year ending 5th April 1819, exhibits at one view the then state of the herring fishery at the different stations in Great Britain, under the superintendence and control of the commissioners, and the officers appointed by them.

No. I.

An Account of the Total Number of Barrels of White Herrings which have been landed from the Fishery, or cured on Shore, in the Year ended 5th April 1819; *in as far as the same has come under the cognizance of the Officers of the Fishery.*

STATIONS.	Quantity and Description of Herrings.							
	Cured for Bounty.			Cured not for Bounty.				Grand Total.
	Gutted with a knife and packed within 24 hours after being taken.	Gutted *not* with a knife and packed within 24 hours after being taken.	Total for Bounty.	Gutted and packed *not* within 24 hours after being taken.	Ungutted.	Barrels of Bulk.	Total Barrels not for Bounty.	
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.		Barrels.	Barrels.
Ayr, Irvine, and Saltcoats	2,806	......	2,806	20	462	90	572	3,378
Campbeltown	3,543	4	3,547	......	1,112½	768	1,880½	5,427½
Fort-William	153½	139½	293	......	......	117½	117½	410½
Glasgow	16,525	137	16,662	63½	610	381½	1,055	17,717
Greenock	24,667	303½	24,970½	31½	124	63½	219	25,189½
Inverary	4,084	55	4,139	10	......	......	10	4,149
Loch-Broom	1,383	134	1,517	1	51	185	237	1,754
——-Carron	1,764½	38	1,802½	35½	325	......	360½	2,163
——-Gilphead	1,456	11	1,467	......	64	34	98	1,565
——-Shildag	1,667½	......	1,667½	72	82	......	154	1,821½
Rothesay	10,020	158	10,178	9	250	149	408	10,586
Stornoway	1,230½	22	1,252½	......	187	86	273	1,525½
Stranraer	1,712½	......	1,712½	......	......	52	52	1,764½
Tobermory	2,832½	22	2,854½	......	534	783	1,317	4,171½
Bristol	187	......	187	......	157½	......	157½	344½
Liverpool	......	......	......	......	134	1,412	1,546	1,546
St Ives	404	80½	484½	......	151	1,071½	1,222½	1,707
Whitehaven	3,481	226½	3,707½	......	916½	64	980½	4,688
Anstruther	6,966	......	6,966	318½	1,424½	329	2,072	9,038
Banff	29,170	......	29,170	150	50	1,027¼	1,227½	30,397¼
Burntisland	3,348½	......	3,348½	......	308	200	508	3,856½
Cromarty	13,953½	......	13,953½	150	3,660½	.....	3,810½	17,764
Eyemouth	18,181½	......	18,181½	......	1,099	420	1,519	19,700½
Fraserburgh	19,482½	700	20,182½	65	2,850½	1,307¾	4,223¼	24,405¾
Helmsdale	21,752½	......	21,752½	465	153	506	1,124	22,876½
Leith	3,301	......	3,301	54	909	......	963	4,264
Lybster	19,628½	......	19,628½	88	1,015	.....	1,103	20,731½
Orkney	8,714	......	8,714	62	1,666½	66	1,794½	10,508½
Port Gordon	14,299	......	14,299	......	167	117	284	14,583
Wick	61,111½	......	61,111½	45	3,129	1,709	4,883	65,994½
Dover	34	......	34	......	46	54	100	134
London	412½	......	412½	......	13	......	13	425½
Portsmouth	1,139½	......	1,139½	44	3,720½	129	3,893½	5,033
Yarmouth	611½	......	611½	......	......	428	428	1,039½
Total	300,023	2,031	302,054	1,684	25,372	11,550	38,606	340,660
Year ended 5th April 1818	......	......	203,285¼	985	15,799	7,621¾	24,405¾	227,691
Difference, year ended 5th April 1819	......	......	98,768¾ Increase.	699 Increase.	9,573 Increase.	3,928¼ Increase.	14,200¼ Increase.	112,969 Increase.

No. II.

An Account of the Total Number of Barrels of White Herrings which have been branded for the Bounty of 4s. *and of* 3s. 9d. *per Barrel, in the Year ended 5th April* 1819.

STATIONS.	For the Bounty of 4s. per Barrel.		For the Bounty of 3s. 6d. per Barrel.		Total Herrings branded.	Amount of Bounty.		
	Bung packed.	Repacked.	Bung packed.	Repacked.				
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	L.	s.	d.
Ayr, Irvine, and Saltcoats	2,074	......	......	......	2,074	414	16	0
Campbeltown	2,525	......	......	......	2,525	505	0	0
Fort-William	95	......	109	......	204	38	1	6
Glasgow	9,161	2,234	......	......	11,395	2,279	0	0
Greenock	7,186½	15,870½	......	295	23,352	4,663	0	6
Inverary	3,616½	......	50	......	3,666½	732	1	0
Loch Broom	1,205½	......	130	......	1,335½	263	17	0
—— Carron	1,516	......	10	......	1,526	304	19	0
—— Gilphead	1,093	......	8	......	1,101	220	0	0
—— Shildag	1,102	......	......	......	1,102	220	8	0
Rothesay	7,910	632	141	......	8,683	1,733	1	6
Stornoway	1,135	......	22	......	1,157	230	17	0
Stranraer	1,503½	......	......	......	1,503½	300	14	0
Tobermory	2,294	......	......	......	2,294	458	16	0
Bristol	......	193	......	......	193	38	12	0
St Ives	244	147	......	......	391	78	4	0
Whitehaven	1,314½	2,152	15	211	3,692½	732	17	0
Anstruther	7,029	332½	......	......	7,361½	1,472	6	0
Banff	15,949½	8,226	......	......	24,175½	4,835	2	0
Burntisland	10,851	8,713	......	......	19,564	3,912	16	0
Cromarty	8,987	1,690	......	......	10,677	2,135	8	0
Eyemouth	6,073	7,422	......	......	13,495	2,699	0	0
Fraserburgh	10,368	3,197	4	242	13,811	2,756	1	0
Helmsdale	7,969	3,801	......	......	11,770	2,354	0	0
Leith	28,983	6,153	......	......	35,136	7,027	4	0
Lybster	7,694½	4,866	......	......	12,560½	2,512	2	0
Orkney	5,979½	2,182½	......	......	8,162	1,632	8	0
Port Gordon	6,927	4,309	......	......	11,236	2,247	4	0
Wick	24,761½	9,772	......	......	34,533½	6,906	14	0
Dover	......	34	......	......	34	6	16	0
London	......	359	......	......	359	71	16	0
Portsmouth	40	517	......	......	557	111	8	0
Yarmouth	395½	......	......	......	395½	79	2	0
Total	185,983	82,802½	489	748	270,022½	L.53,973	11	6
Year ended 5th April 1818	131,123½	50,875	658	433	183,089½	36,590	12	6
Difference, year ended 5th April 1819	54,859½ Increase.	31,927½ Increase.	169 Decrease.	315 Increase.	86,933 Total incr.	L.17,382 Increase.	19	0

No. III.

An Account of the Total Number of Barrels of White Herrings which have been exported from Great Britain in the Year ended 5th April 1819, *in as far as the same have come under the cognizance of the Officers of the Fishery.*

STATIONS.	Exported to Ireland.		To other places in Europe.		To places out of Europe.		Total Exported.
	Gutted.	Ungutted.	Gutted.	Ungutted.	Gutted.	Ungutted.	
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
Ayr, Irvine, and Saltcoats	165	487	...	...	...	...	652
Campbeltown	1,112	1,407	...	...	...	...	2,519
Fort-William	385	60	...	...	...	...	445
Glasgow	5,829	614	100	...	...	...	6,543
Greenock	3,821½	163	...	...	27,642	91	31,717½
Loch-Broom	165	60	...	...	...	...	225
Loch-Shildag	1,105	...	...	...	...	...	1,105
Rothesay	1,186	294	...	...	...	...	1,480
Tobermory	3,216	1,383	...	..	...	...	4,599
Bristol	969	148	...	...	4,872	186	6,175
Liverpool	134	...	...	...	2,198	1,317	3,649
St Ives	172	...	...	...	...	...	172
Whitehaven	655	325	...	...	2,397	177	3,554
Anstruther	2,069	470	600	...	...	...	3,039
Banff	4,031	...	10,822	...	...	...	14,853
Burntisland	2,855	252	5,463	...	...	...	8,570
Cromarty	2,258	665	500	...	...	...	3,423
Eyemouth	1,770	...	...	...	...	...	1,770
Fraserburgh	4,439	332	3,705	...	611	54	9,141
Helmsdale	2,062	...	3,580	...	...	...	5,642
Leith	9,674	1,060	22,222	...	1,638	50	34,644
Lybster	465	...	926	...	...	...	1,391
Orkney	3,452	1,330	...	...	800	200	5,782
Port Gordon	2,600	...	1,035	...	...	...	3,635
Wick	17,869	520	3,170	...	..	...	21,559
London	4,707	...	310	...	42,595	277	47,889
Portsmouth	30	2,938½	...	...	20	...	2,988½
Total	77,195½	12,508½	52,333	...	82,773	2,352	227,162
Year ended 5th April 1818	44,304½	9,082	43,368	528	60,475	4,582	162,339½
Difference, year ended 5th April 1819	32,891 Increase.	3,426½ Increase.	8,965 Increase.	528 Decrease.	22,298 Increase.	2,230 Decrease.	64,822½ Total Increase.

Progr of the H- land fi ery.

This rapid progress shows that there is no art or mystery in the catching and curing of herrings that the English cannot attain as well as the Dutch; and the same thing is further proved by the successful experiment made by the Downs Society of Fishermen, in the report of whose proceedings it is stated that herrings had been taken within the Cinque Ports of a quality so nearly resembling the deep-sea fish, that they were cured and sold as the best Dutch herrings. It will also be seen by Table I. that the progressive increase of the herring fishery is confined to Scotland; and that the quantity brought under the inspection of the officers in England amounts not to one twenty-second part of the whole; whilst the flourishing little town of Wick alone furnishes nearly one fifth. But the most extraordinary increase is that which has taken place in the neighbouring county of Sutherland. Formerly the people of this county were contented to hire themselves as fishermen to the adventurers of Wick. In 1814 they attempted a fishery on their own account, and the mouth of the Helmsdale river was fixed upon as the station. A storehouse and curing-house were here erected; and the boats were manned by the people brought from the mountains and the interior of the country. Every thing was new to them in the employ they were about to engage in. The fishing commenced on the 20th July, and ended on the 3d September 1814; and the produce of four boats was respectively L.105. 3s., L.83. 8s., L.96. 8s., and L.148. 3s. They were manned by four men each, so that they made, on an average, rather more than L.27 a man. In 1815 the number of boats employed amounted to fifty, almost entirely manned by Sutherland men; and the number of barrels caught and repacked exceeded 4000, chiefly gutted. In 1817 this fishery gave employment to about 200 tenants, seventeen coopers, and 130 women; in 1818 to seventy coopers, 520 women, 700 men, 140 boats; and, in the year 1819, the quantity caught and cured at Helmsdale, as appears by the table, amounted to no less than 22,876 barrels, besides upwards of 100,000 cod and ling. Whilst the herring fishery was making these rapid strides in the Highlands of Scotland, the ancient town of North

Yarmouth, which owes its existence to the herring fishery, and in the time of Edward III. had an act, usually called "the statute of herrings," passed in its favour, for the regulation of its herring-fair, exhibited only the small number of 1039 barrels.

White fishery.

And not only does North Britain take the lead in the herring-fishery, but it has also availed itself of its favourable situation for carrying on that branch which may be reckoned next perhaps in importance, namely, the cod and ling fishery. The whole extent of sea, from the neighbourhood of the Orkney and Zetland Islands, to Iceland on the one hand, and to the coast of Norway on the other, and along the eastern and western shores of Scotland, to the Flemish banks on the east and the coast of Ireland on the west, may be considered as one great fishing domain, over which the different species of the cod genus are most plentifully dispersed; as are also turbot, skate, soles, haddocks, and whitings. These fish, which constitute collectively what is usually called the *white fishery*, surround as it were the whole of North Britain, and give to that portion of the united kingdom advantages which its southern neighbours cannot boast of.

Turbot fishery.

The only fishery perhaps which neither the Scotch nor the English follow up with the same success as the Dutch, is that of the turbot, the finest of which are supposed to be taken upon the Flemish banks. The turbot fishery begins about the end of March, when the Dutch fishermen assemble a few leagues to the south of Scheveling. As the warm weather approaches, the fish gradually advance to the northward, and, during the months of April and May, they are found in great shoals on the banks called the Broad Forties. Early in June they have proceeded to the banks which surround the small island of Heligoland, off the mouth of the Elbe, where the fishery continues till the middle of August, when it terminates for the year. The mode of taking turbot is as follows: At the beginning of the season the drag-net is used, which, being drawn along the banks, brings up various kinds of flat fish, as soles, plaice, thornbacks, and turbots; but when the warm weather has driven the fish into deeper water, and upon banks of a rougher surface, where the drag-net is no longer practicable, the fishermen have then recourse to the hook and line. Each line extends from one to nearly three miles in length, and is armed with six, seven, or eight hundred hooks, fixed to it at the distance of several yards from each other. To keep these long lines properly stretched, and prevent their being carried away by the tide, heavy masses of lead in some places, and small anchors in others, are attached to them. The hooks are baited with the common smelt, and a small fish resembling an eel, called the gorebill. Though very considerable quantities of this fish are now taken on various parts of our own coasts, from the Orkneys to the Land's End, yet a preference is given in the London market to those caught by the Dutch, who are supposed to have drawn not less than L.80,000 a year for the supply of this market alone; and the Danes from L.12,000 to L.15,000 a year for sauce to this luxury of the table, extracted from about one million of lobsters, taken on the rocky shores of Norway, though our own shores are in many parts plentifully supplied with this marine insect, equal in goodness to those of Norway.

Salmon fishery.

Scotland has very decidedly the advantage over England in the salmon fishery, which, if not of superior value, may be allowed to rank next in importance to the cod fishery. This fish being rarely caught except in estuaries or rivers, may be considered as in a great degree private property; and it may therefore be presumed that the fishery is conducted to the greatest possible extent and advantage. From the extremity of the Highlands, and from the Orkney and Zetland Islands, these fish are sent to the London market, as before mentioned, in ice; and when the season is at its height, and they catch more than can be taken off hand fresh, they are then salted, pickled, or dried, for winter consumption at home, and for the foreign markets. Perhaps the fishery of the Tweed is the first in point of the quantity caught, which is sometimes quite astonishing, several hundreds being taken at a single draught of the net. It is here where the kitted salmon is principally prepared for the London market, being first boiled and then pickled with vinegar.

The decrease of salmon in the English and Scotch rivers, particularly of late years, is a fact as to which there can be no manner of doubt. Much unsatisfactory discussion has taken place as to its causes, which are probably of a very diversified character. A good deal has been ascribed to the increase of water machinery on the banks of the different rivers; but we hardly think that this could have much influence, except perhaps in the case of the smaller class of rivers. *Weirs* or salmon traps have also been much objected to; though, as we have been assured, with still less reason. On the whole, we are inclined to think that the falling off in the supply of this valuable fish is principally to be ascribed to the temptation to over-fish the rivers, caused by the extraordinary rise in the price of salmon; to the prevalence of poaching; and, more than all, to the too limited duration of the *close time*. In 1828, after a great deal of discussion and inquiry, an act was passed (9 Geo. IV. c. 39), which has done a good deal to remedy these defects, in as far at least as respects the Scotch fisheries. The rivers are to be shut from the 14th of September to the 1st of February; and every person catching or attempting to catch fish during that period is to forfeit not less than L.1 and not more than L.10 for every offence, besides the fish, if he have caught any, and such boats, nets, or other implements as he may have made use of. Pecuniary penalties are also inflicted upon poachers and trespassers; and provision is made for the watching of the rivers. We understand that this act has upon the whole had a very good effect; though it is believed that it would be better were the *close time* extended from the 1st of September to the middle of February.

The late Sir Humphry Davy delivered into the hands of the committee a paper on the natural history of the salmon, which he concludes with the following observations. "There is a general complaint," he says, "of the diminution of salmon in fisheries. In the Thames it can scarcely be said to exist; and even in the Avon, the Severn, and the Trent, it is becoming comparatively a scarce fish. The great northern fisheries, and the Irish fisheries, are much less productive than formerly." The simple remedies for this national evil he states to be, 1. to suffer more fish to spawn, and fish of all ages and sizes; 2. to prevent any fish from being killed in rivers after spawning; and, 3. to prevent the young salmon or salmon fry from being killed.

He is of opinion that each variety of salmon or salmon trout affects a particular river, and always returns to it; that therefore all stake fishings should be abolished, as they enable persons having no interest in the river to cut off almost entirely the supply of fish, for salmon do not go far out into the sea, and always return along the coast, scenting out, as it were, their own river; and that a strong net put across an estuary might destroy in one year the whole fishery of a river. He recommends that no close wears should be allowed, but that there should be always a free passage for fish, so that early fish may go up as well as late fish; that no machinery should be allowed in a river, by which spawning fish may be killed; that nets should be limited to a certain size, so as to render it impossible to sweep a river; and that no angling should be allowed in salmon rivers till May, nor after October.

The annual value of the Scotch and English fisheries, and the number of persons and craft employed on them, are but vaguely stated in the statistical reports of the several maritime counties of Great Britain; and in some of them the subject, important as it certainly must be considered in our economical system, and as connected intimately with the subsistence and employment of the labouring poor, is altogether omitted. This defect is more particularly to be regretted at this moment, when inquiries are anxiously making, not only how to employ a superabundant population, but to ascertain to what extent the powers of the country are capable of supplying the means for its subsistence. Indeed we conceive that a statistical survey of the British fisheries, as far as it could be made out, would afford a most valuable document in aid of a more complete investigation of that branch of political economy which relates to the employment and the feeding of the people. The following brief account must, therefore, be considered as very imperfect. It is to be understood that the returns of the herring fishery, as given in the preceding table, are not taken into the account.

Sutherland. The waters in which the salmon fishery is chiefly carried on in this county are those of Naver, Helmsdale, and Brora, and the rent of these fisheries is about L.1700 a year; the produce L.6800. In one year, from December to March inclusive, were caught between Bighouse Bay, on the north coast, and Rou-stoir in Assynt, on the west coast, 30,000 lobsters, which at three pence a piece, the price paid to the fishermen, amounted to L.375. They were carried in smacks to the London market, where at that season of the year their value was estimated at about L.7000. It is estimated that each of the thirty-seven boats on the coast of Assynt might produce L.100 a year. Three boats at Golspie are stated to make about L.150 a year by haddocks alone, which are consumed by the country people. Of the quantity of cod and ling exported no account is given, but these valuable fish are taken in great abundance on every part of the coast. Whatever opinions may exist with respect to the policy of the measures which have recently been adopted regarding the tenantry of this county, there can be but one in considering the late Duke of Sutherland as a great promoter of the fisheries, and a benefactor to all who are concerned in them.

Caithness. It is asserted, with every probability of truth, that there is no district in Europe better calculated for carrying on the fisheries, either in point of profit, variety, or extent, than Caithness. In the fresh waters of the county, and the seas by which it is surrounded, there are enumerated forty-five different kinds of esculent fish. Next to the herring, the cod fishery, near Thurso, may be reckoned as the most important. Indeed the whole coast of Wick and Latheron, and every part of the Pentland Frith, abounds with this valuable species of fish, as well as all the other kinds usually distinguished by the name of white fish. The herring fishery, as will be seen in the preceding table, holds a high place among the established fishing stations; and, in fact, the whole county feels the beneficial effects of an active prosecution of the fisheries, out of which has of late years risen a new town, near Wick, named Pulteney Town; and all the villages on the coast are in a progressive state of enlargement and improvement from the same source.

Ross and Cromarty. In the report of the agriculture of these counties, by Sir George Mackenzie, there are some excellent observations respecting the herring fishery, the decline of which, previous to the late act, he ascribes to the circumstance of salt being delivered to the fishers free of duty; which made the fishermen rely on the greater part of their expenses, and some part of their profits, being paid by the fraudulent practice of smuggling the salt for sale; and to such an extent was this practice carried, that it is broadly asserted "there is not a farmer in the Highlands who uses any other than fishery salt for butter, cheese, and other provisions; there is no other salt used in private families."

The cod fishery of Gairloch is the most productive of any upon the coast of Scotland. The fishing is from January to April. The fish are small in size, but rich, averaging about five pounds each when cleaned for salting. They are mostly pickled, and also dried, and sent to Ireland, Liverpool, and London. The average annual produce is about 20,000 cod, taken by twenty boats, each having about 400 hooks; which number, it is stated, might easily be doubled. For the success of this fishery, those who followed it were greatly indebted to the bounty and judicious assistance of Sir Hector Mackenzie.

Nairn and Moray. The principal fishery of this part of North Britain is that of salmon, chiefly in the rivers Nairn, Findhorn, and Spey, the whole of which, supposed to amount yearly to about L.25,000, is exported to the London market in smacks of eighty or a hundred tons burden, packed to the number of three or five in a box with pounded ice. These smacks keep the sea in all kinds of weather, and generally reach their destination from the fifth to the ninth day. When salmon begins to be too plentiful in the market, it is then boiled and sent up in kits. The price is so high where caught, that salmon is considered as a luxury, and is exhibited only at a feast.

Aberdeen. The salmon fishery is the most considerable in this county, and most productive on the Dee and the Don. The usual practice, formerly, was to salt the fish, pack them in barrels of about four hundredweight each, and export them to the south of Europe. In 1798 the quantity caught on the Dee was equal to 1890 of these barrels, and on the Don 1667 barrels. At present they are sent up fresh to the London market; and it is stated that the price, since 1768, has increased in a five-fold proportion, and that not more than one pound of salmon is consumed in the county for forty that are exported. The fishings on the Ugie, the Ythan, and the coast near these rivers, vary from 200 to 600 barrels. The ordinary sea fishing for haddocks, cod, ling, skate, turbot, halibut, &c. is stated to employ a number of fishermen, who carry on their occupation chiefly in small creeks, and that it brings in yearly from L.15,000 to L.30,000, the greater part of which is consumed within the county; excepting about 500 barrels of cod, and a considerable quantity of ling, exported from Peterhead; from which place also, and Aberdeen, the Greenland whale fishery has been carried on with great success. The whole of the fisheries connected with the county yield from L.80,000 to L.100,000 annually.

Kincardine. The sea fishing, or white fishery as it is usually called, is stated to have greatly fallen off in this county. In upwards of thirty miles of sea-coast, the annual value of the white fish caught, and chiefly consumed in the county, does not exceed L.6000, giving employment to about 303 fishermen, or 200 families, consisting of 900 souls. The number of boats is about forty-three, and of yawls twenty-seven. The salmon fishery is of more importance; that in the North Esk is farmed at upwards of L.2400 a year. This, however, is the principal fishery, all the other waters in the county not producing a rental of more than L.300 a year.

The Lothians. Excepting a limited herring fishery at Dunbar, and a local fishery for the scanty supply of the neighbouring towns, the only other fishery deserving of notice, as a branch of trade, in East Lothian, is the oyster fishery at Prestonpans. From this place there have been sent to fatten, in bays near the mouths of the Thames and Medway, thirty cargoes in one season, each cargo consisting of 320 barrels, and each barrel containing 1200 saleable oysters, which brought about L.2500; but the quantity consumed near the spot, and in Edinburgh, brought somewhat more, and this branch of trade gave occasional employment to about forty boats. In that part of the Frith of Forth which washes the coast of West Lothian, besides a herring fishery on a limited scale, a scanty supply of cod, haddocks, whitings, skate, flounders, crabs, lobsters, and oysters, is taken for the use of the neighbouring towns.

Dumfries. The only fishery of any importance in this county is the salmon fishery in the Solway Frith, and the rivers, chiefly the Annan, falling into it, the rents of which do not exceed L.1400 a year, and are supposed to be too high; the fishing having greatly decreased in consequence of the destructive engines made use of by the renters. It is stated by one gentleman, that the number of salmon taken is not equal to one in a hundred of those caught some forty years ago.

Inverness. The salmon fisheries in the lochs and rivers of this county are those of most importance, and let for about L.3000 a year. Those on Loch Beauly and Loch Ness are the most valuable. A singular method of taking salmon is described near Invermoriston, where the river flows in a narrow chasm between two projecting rocks: "The fisherman seats himself on a cleft of this rock, right over the cascade, with a spear in his hand, which has a line fixed to the upper end of the shaft, similar to the practice of fishing for whales with harpoons. Whenever the salmon makes a spring to gain the ascent over the cataract, the spearman strikes the fish and lets the shaft go, holding only by the line until the fish has exhausted his strength; then the spear and fish are thrown ashore by the stream, and taken out at the lower side of the pool."

Argyle. The whole of this county is so intersected with sounds, straits, lochs, and rivers, that the fisheries might be carried on within them to almost any extent; and fishing is accordingly the occupation of a great number of its inhabitants, there being in the whole about 1500 fishing-boats employed, of which Lochfine alone employs 600. The value of the fish caught is stated to be from L.40,000 to L.50,000 annually.

The Hebrides. The following is the whole account of the fisheries of these numerous islands, contained in the *Agricultural Survey:* "These fisheries," says Mr Macdonald, "do not belong to an agricultural survey; but they are of very essential importance to the Hebrides, and therefore merit notice in this place. They bring into those isles L.200,000 a year, at an expense perhaps of L.120,000, that is, they yield a clear profit in money and sustenance of L.80,000 to the natives. They occupy, together with the kelp manufacture, 2562 boats and vessels of every description, and for some months in the year 10,500 sailors. The fencible men, or those between the age of sixteen and twenty, being one fourth of the population, are 22,762; so that nearly one half of the effective male population is connected with the fishery. The principal fishing ports are Rothesay in Bute, Stornoway in Lewis, Tobermory in Mull, and Portnahaven in Islay; but the districts of Harris, Barray, South Uist, Skye, and various other islands, fit out a number of boats annually, or supply the Clyde busses with excellent mariners and fishermen."

English fisheries.

Berwick. London, it has been already observed, receives a very considerable portion of its fresh salmon from the fishery on the Tweed, that on the English side of the river alone giving employment to seventy small boats and about 300 fishermen. The value is not mentioned, but it is stated, in the *Survey of Durham*, that the rents amount to L.15,766 annually, and that, so far back as 1807, the number of boxes sent to London was 8445, of eight stone each, or 67,560 stone, which, at 16s. a stone, is L.54,000; besides what is killed for exportation, and what is sold fresh in the neighbourhood. The salmon, as they are caught, are packed in ice and sent away in the vessels well known under the name of Berwick smacks. Formerly it was all pickled and kitted, after being boiled, and sent to London under the name of Newcastle salmon; but the present mode has so raised the value of the fish, as nearly to banish this article of food from use among the inhabitants in the environs of the fishery, excepting as an expensive luxury. Within memory, salted salmon formed a material article of economy in all the farm-houses of the vale of Tweed, insomuch that in-door servants often bargained that they should not be obliged to take more than two weekly meals of salmon. It could then be bought fresh at 2s. the stone, of nineteen pounds weight; it is now never below 12s., often 36s., and sometimes two guineas, the stone.

The coast fishery is not of very material importance. It gives employment to upwards of 100 fishermen, at eight small fishing stations, with about twenty boats. The fish-carriers, under the name of *cadgers*, purchase and distribute the white fish, codlings, haddock, whitings, skate, halibut, and flounders, with a very few turbot, into the inland country, and often as far as Edinburgh. Cod and ling are generally contracted for, by the season, at a fixed price, by the fish-curers, who either salt and dry them, or barrel them, as the weather may serve. The fisheries on the coasts of Cumberland, Northumberland, Yorkshire, and Lancashire, are not once adverted to in the agricultural surveys of these counties.

Durham. The salmon fisheries in the Tyne, the Wear, and the Tees, are stated to have declined very much of late years, in consequence, it is supposed, of dams being thrown across these rivers, which prevent the fish from getting up to spawn.

Lincolnshire. On the coast of this county the fisheries appear to be almost wholly neglected. There is a little fish, however, in the east and west fens, called a stickleback, so numerous, that a man may make 4s. a day by selling them at a halfpenny a bushel. They also come from the sea into Boston Haven, where they are purchased for manure, being more powerful than any other kind known, even that of the whale refuse. It is almost unnecessary to state that, in this fenny county, pike, carp, perch, and tench, are most abundant.

Norfolk. The Norfolk surveys take little notice of the fisheries. It appears that the sticklebacks are caught in immense quantities in the Lynn river, about once in seven years, and are purchased for manure at the rate of sixpence or eightpence a bushel. It is mentioned, however, in Kent's *Norfolk*, that herrings to the amount of L.50,000 are annually exported, but that fish for the use of the inhabitants are neither regularly supplied nor cheap; that the best fish are lobsters, soles, and cod; that the whitings are small, and the oysters very large.

Suffolk. Besides the herring fishery carried on from Lowestoffe, by forty or fifty boats of forty tons each, the mackerel fishery is pursued during the season with great vigour. The value of this fish, caught in the course of six weeks, is stated to exceed L.10,000, independently of the usual kinds of white fish for the supply of the neighbourhood and the London market, the total value of the fishings being not less than L.30,000 a year. Most of the herrings caught here are dried and sent to the ports of the Mediterranean.

Essex. The oyster fishery is of all others the most important to this county. The principal station of the dredging-boats is at Mersea in Blackwater, which, with the Crouch and the Coln, are the most extensive breeding rivers in Essex. The oysters are brought from the coasts of Hampshire, Dorset, and other maritime counties, even as far as Scotland, and laid in the beds or *layings* in the creeks adjoining those rivers. The number of vessels immediately employed in the dredging for oysters is about 200, from twelve to forty or fifty tons burden each, employing from 400 to 500 men and boys. The quantity of oysters bred and taken in this county and consumed annually, mostly in London, is supposed to amount to 14,000 or 15,000 bushels. All the other fisheries connected with this part of the coast are stated to employ a capital supposed to amount to from L.60,000 to L.80,000.

Middlesex. This county, having no fishery of its own, but the very trifling one afforded by the Thames, is infinitely the greatest consumer of fish, and demands a larger supply than all the rest of the empire together. By a return of the cargoes of fish brought by water to the Billingsgate market, it appears that, on an average of six years ending 1785, the number of cargoes amounted to 1569, and of four years ending with 1803, the average was 2428; the average tonnage being about fifty, and the general average of fish in each about forty tons, which will give nearly 100,000 tons of fish. Supposing the quantity brought by land carriage to be one fifth of the other, the whole weight of fish brought to the London market would amount to the enormous quantity of 120,000 tons a year, which, supposing the capital and its environs to contain 1,200,000 inhabitants, would allow 200 pounds of fish annually to each individual; and, of course, a very considerable quantity must be dried or salted fish for exportation, if the returns be at all correct.

Kent, Sussex, Hampshire, and Dorset. In the *Agricultural Surveys* of these counties, little notice is taken of the fisheries; in the first they are not even mentioned. In Sussex, the produce of the ponds in carp, tench, and perch only are noticed; and even these, it would seem, are monopolized by a London fish-dealer. In the rivers of Hampshire the salmon fishery is carried on, but to no great extent. The little town of Hamble, situated on the shore of the Southampton water, has about twenty sail of well and other boats constantly employed in fishing, and which go as far as the Scilly Islands and the Land's End for lobsters, crabs, and craw-fish in the season. In the winter they dredge for oysters, and for about a month catch vast quantities of herrings round the Isle of Wight, the waters of which also afford employment in the whitings, plaice, prawns, shrimps, lobsters, and crabs, with which they abound. Southampton market is generally well supplied with all kinds of fish, and Portsmouth pretty well, but not equally so with the former place. The town of Poole in Dorset is deeply engaged in the Newfoundland fishery. Along the sea coast of all these counties, the mackerel fishery during the season, and the taking of the various kinds of white fish, especially soles and whitings for the London market, and the supply of the neighbouring towns, occupy a very considerable portion of the inhabitants of the former place.

Devonshire. The supply of salmon in the waters of Devon was formerly so abundant, that here too the farm servants found it necessary to stipulate that they should not be obliged to eat salmon more than twice a week; but the case of late years is widely altered, the fishery having fallen off so as to be of little or no importance. This is stated to be owing to a wasteful and improvident destruction of the species, by taking the young fish on their return seaward towards the end of the year; no less than a thousand having been taken in one week at Brightley on the river Taw, where, and at Umberleigh, it has been usual for the young salmon fry, or gravellers, to be given to the pigs.

The sea-fishery is conducted with a considerable degree of activity in this county, Brixham alone having no less than 100 sail of vessels employed in the fisheries. Soles, whitings, flounders, gurnet, john dories, and the red mullet, are caught in great abundance and of the finest quality, and sent off to London, Bath, and Bristol, also to Plymouth, Exeter, and the neighbouring towns; and when, in the summer season, the quantity taken is greater than can be disposed of, the fish are well cleaned, salted, and dried in the sun: thus prepared, they take the name of *buckhorn*, and are esteemed an excellent relish, much sought after in the navy, and also along the French coast.

Cornwall. In addition to the different kinds of fish which are taken off the coast of Devon, Cornwall has the advantage of an annual visit of vast shoals of pilchards, equally abundant, for the space they cover, with the shoals of herrings. The four principal ports from which the pilchard fishery is carried on are, Fowey, Falmouth, Penzance, and St Ives. At Polperro, which is perhaps the smallest establishment, upwards of forty boats and nearly 200 fishermen are engaged in the hook and line fishery; and the aggregate value of the fish taken is supposed to amount to L.5000 annually, most of which is distributed all over the country to the distance of thirty miles, by men and women carriers. The markets of Exeter and Bath, Plymouth, Liskeard, Tavistock, and other places, receive supplies from hence; and lobsters are delivered to the Southampton well-boats for London. The neighbouring poor are supplied almost all the year round with fresh and salted pilchards. Indeed the multitudes of these fish taken on the coast of Devonshire, as well as Cornwall, are enormous between the months of July and September inclusive, when the whole line of coast presents a scene of bustle and activity. The fish for foreign export and winter consumption are laid up on shore in large stacks or piles, with layers of salt between each row; here they are suffered to lie for twenty or thirty days, during which time a vast discharge of pickle mixed with blood and oil takes place, all of which is carefully caught in pits, and preserved for manure, which is eagerly purchased by the farmer and carried away in casks. It is said that every pilchard will dress and richly manure one square foot of ground. The fish are then carefully washed with sea-water, dried and packed in hogsheads, in which state they are sent abroad. The average value of pilchards taken in one year in Cornwall is supposed to be from L.50,000 to L.60,000.

The pilchard fishery has indeed been long of great importance to the inhabitants of the coast of Cornwall, the quantity taken by *seine* nets in some years having amounted to the enormous extent of 50,000 hogsheads; but it has not, on an average of the last fifteen years, exceeded half of that quantity. This, as before stated, is very much owing to the heavy duties imposed by the government of Naples; but the practice of driving the fish, and taking them by what are called drift nets, is considered as most injurious to the more important fishery by the seine.

The pilchard is supposed not to be a fish of passage, but to remain off the coast, in deep water, when not frequenting the bays. At such times they move about in large bodies of separate and distinct shoals, each shoal having, it is supposed, leading fish to direct them; indeed they are known to have a lively instinct of danger, and to leave the shore on the least interruption and noise. A few years ago, when an experimental squadron was manœuvring in the Channel, on exercising the great guns, the inhabitants of Cornwall complained that the pilchards had wholly disappeared, and requested that the practice of firing might be discontinued. It is this sensitiveness of the fish that makes the drift nets so particularly objectionable, the drivers following the shoals, and constantly interrupting their progress, diverting and dispersing the shoals, and preventing them from coming into shallow water.

The principal fishing station between Plymouth and Falmouth is Mevagissey, whence in the year 1818 about forty seines were sent out, which have since been reduced to about twenty, employing not more than about 330 men and 40 boys; but the employment given on shore to men, women, and children, is said to comprehend, directly and indirectly, nearly the whole population of the place. The original cost of each seine or concern is about L.1000 a float, and the capital on shore about L.500; so that the total outlay of the twenty seines will amount to L.30,000. Formerly these twenty seines would land in favourable seasons 10,000 hogsheads, which are said of late years scarcely to exceed 1000 hogsheads. The driving boats are stated to be about twenty-three, having two men, and in some instances two men and a boy, in each boat. The cost of a boat and nets may be from L.50 to L.100. The fish they catch are conveyed chiefly to the home market. Yet, insignificant as it appears to be, it is stated that the important branch of the fishery with the seine is fast sinking under the lawless proceedings of the drivers, which in the end must be its total ruin, unless it be protected by the government, or some more effective legislation. Why do none of the Cornish members take some steps to remedy this crying evil? Here there are no foreign competitors, but this valuable branch of the fisheries is impaired and threatened with destruction by the conflicting interests of our own countrymen.

Somerset. The salmon and herring fisheries of Porlock, Minehead, Watchet, and other places on the shores of the Bristol Channel, are stated to have been carried on to a considerable extent since the duty on salt used for curing fish for home consumption was removed; and the increase of the latter fishery has been the means, not only of furnishing employment during the winter for the seamen, who are engaged in the lime, stone, and culm trade during the summer, but of providing a cheap and wholesome food for the labouring class of inhabitants.

Fisheries of Wales.

The great extent of coast, washed by the sea, and the numerous fine streams and navigable rivers by which it is intersected, give to the principality of Wales the advantages of fisheries little if at all inferior to those in Scotland. In South Wales, Milford Haven, and its tributary streams, the Towy and its branches, the Laughor, the Teivy, and the Dovy, all navigable, abound with the finest salmon, sewin, trout, samlets, &c.; and the same kind of fish are equally plentiful in the twenty-two inferior streams, which fall into the sea on the coasts of the four maritime counties of Glamorgan, Caermarthen, Pembroke, and Cardigan. The value of the salmon sent to Bath and Bristol from Monmouth alone, the produce of the Wye, Usk, and Rumney, is said to exceed L.4000 annually, exclusively of what is consumed in the county. The sea affords them annual shoals of herrings, which, with potatoes, is one of the chief articles of sustenance for the poor. They first appear in the bay of Cardigan towards the middle of September, just as the harvest is finished. The other sea fish are cod, haddocks, whitings, skate, ray, turbot, plaice, flounders, soles, mullets, gurnards, mackerel, dories, shad, &c. Shell-fish of all kinds are most abundant, and in various parts of Milford Haven there are inexhaustible beds of oysters of superior excellence. Those of Tenby and other parts of the coast are of enormous size, but of inferior quality to those taken in Milford Haven.

It is worthy of remark, that the *sewin* is a fish peculiar to South Wales, and is not found in any river east of the Wye, or north of the Teivy, but frequents all the intermediate rivers, which they visit annually about the beginning of June, and continue in season till the end of August, weighing from one and a half to four or five pounds each. The samlet is a small fish about nine inches long, frequenting all the rivers in which salmon and trout are found; and it has been concluded, from the circumstance of a female samlet being utterly unknown, that they are the hybrid offspring of the female salmon and the male trout. As an article of food, they are excellent when fried, potted, or pickled.

In North Wales the sea fish are of the same description as those of the southern coast; and the herring fishery in the bay of Caernarvon is, perhaps, the most flourishing in all Wales; but the badness of the roads, and the distance by sea from any great market, check the demand for fish, and discourage the people from following the occupation. A good road from Caernarvon into Shropshire, to open a direct and speedy conveyance to the heart of England, where sea fish is scarcely known to nine tenths of the community, would be the means of increasing the demand for this palatable and wholesome food, of which the supply along the extensive coast of North Wales is inexhaustible.

Irish eries.

The sea coasts of Ireland are as abundant as, and perhaps more so, in every valuable species of fish, than those of Great Britain. Its numerous bays, creeks, inlets, lakes, and rivers, swarm with them. It is visited annually by vast shoals of herrings; and the banks near its shores are well stored with excellent cod, hake, and ling, equal in all respects to those caught upon the banks of Newfoundland. With the westerly winds, which may be reckoned to blow for nine months in the year, the produce of these fisheries might always be sent to ready markets at Bath, Bristol, Liverpool, and other great towns on the western and southern coasts of England; yet, either from indolence, want of inclination, or, which is more probable, want of capital, and most of all from want of proper regulations, the Irish have hitherto done little more than procure from their fisheries a scanty supply for the chief towns, and the families of those who are resident near the coast. It would seem, indeed, that the Irish have not much taste for a seafaring life, few of their young men volunteering for the navy, whilst they go in shoals into the army; and those few who follow the occupation of fishermen are so much prejudiced in favour of their own clumsy methods of proceeding, as to resist all attempts at improvement. It is stated by Mr Whately, in his *Hints for the Improvement of the Irish Fishery*, that, when the trammel net was attempted to be introduced, by which, in a couple of hours, more fish might be taken than with their hookers in a whole night, such was the prejudice against this new mode of fishing, that the crews of the hookers, alarmed at the supposed diminution of their profit by the increased supply, combined together along the whole coast, and destroyed the trammel nets wherever they were discovered. There is, however, a species of trall, not commonly made use of, which, according to the opinion of Mr Mitchell, is highly injurious to the Irish fisheries.

"The common method of fishing in this manner on the coast," says this author, "is with what they call a beam-trail, or trall, which consists of a large beam or pole, generally between twenty and thirty feet long, headed at both ends with large flat pieces of timber, which resemble the wheels of a common cart; except that, instead of being round, like them, they are rather semicircular, or resembling a heart cut in two, lengthways. They are shod, like the wheels of a cart, with iron. To this beam the trail net or bag is fixed, and at each end ropes are fastened, by the help of which the ground is entirely swept so clean, that I have been assured a fisherman will venture to throw his knife or any such small matter overboard, in thirty or forty fathom water, and readily take it up again; and thus the ground is swept clean for a considerable tract, at every put, as they call it, the boat commonly sailing a mile, or perhaps a league, before the bag and beam are hauled up.

"It has great inconveniences; for, 1*st*, it sweeps and tears away all the sea plants, moss, herring-grass, &c. which some fish feed on, making those species to seek elsewhere for food; 2*dly*, it disturbs and affrights the larger kinds of fish, as cod, ling, &c. in the same manner as if pursued by larger fish of prey; and, 3*dly*, which is worse than all, these beam nets, and others of the kind which are dragged along the ground, tear away, disturb, and blend up the spawn of many kinds of profitable fish, in a terrible manner; and often many hogsheads of their spawn are drawn up in the trall bags, in which may be distinctly seen several thousand embryos of young fish."

Under proper regulations, the Irish herring fishery would no doubt equal, if not exceed, that of North Britain. At present no pains are bestowed in the salting and gutting of the fish. In some parts of the coast they are thrown into holes dug in the earth, and there salted, whence they are sent in bulk to Cork and other places, to be put into barrels. Loch Swilly is one of the principal bays for the herring fishery. The salmon fisheries in the north of Ireland might be rendered very valuable. That of Coleraine is, perhaps, the most productive; from five hundred to nearly a thousand fish being sometimes taken at a single draught. They are mostly pickled for exportation.

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If the information be correct which is stated by Mr Fraser, in *A Letter to the Right Honourable Charles Abbot*, nothing can more strongly exemplify the beneficial effects arising from the free use of salt without being subject to bonds, pains, or penalties, than those derived from the privilege granted by parliament to the inhabitants of the Isle of Man, to import salt from England duty free, not only for curing fish, but for all other domestic purposes. "In the year 1784," says Mr Fraser, "I had the honour to be appointed by the Treasury to make an inquiry into the state of the revenue and fisheries of that island. I found that, at that period, without bounties on their boats, or the tonnage of their fishing smacks, or any premiums other than the free use of salt, they carried on a most extensive fishery, which employed 2500 seamen. In the absence of the herrings, the fishermen supplied the consumption of the island in great abundance with white fish; the agriculture was greatly increased, and the population consisted of 30,000 souls, having nearly doubled the number of its inhabitants in fifteen years." It further appears, from the *Report of the Committee of the House of Commons for the Fisheries in* 1798, that their boats had increased, both in number and size; that from a burden of ten or twelve tons, they had now advanced from sixteen to twenty-two tons, of which the number exceeded 350, each employing seven or eight men; that they had, besides, from forty to fifty fishing smacks from twenty to forty tons each, the whole employing upwards of 3000 seamen, which were then equal to the number of men and boys employed in the whole of the buss fishery of Scotland, supported by bounties to the extent of L.20,000 a year.

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The fish which we have said to be next in importance to the herring in point of value, is perhaps not inferior to it in point of numbers. Like it, too, the cod is supposed to be migratory, though confined chiefly within the limits of 44° or 45°, and 68° or 70° of latitude, and is found generally on banks covered with a considerable depth of water; and the deeper the water the better is the quality of the fish. It is for this reason that the great Banks of Newfoundland, those near Ireland, the coast of Norway, the Orkney and the Zetland Islands, and other banks in the North Sea, the principal of which are the Wellbank, the Doggerbank, and the Broad Forties, are resorted to as the most favourable spots for the cod fishery. Of all these, however, the Banks of Newfoundland are most esteemed, and are, in consequence, the general fishing grounds of all European nations, more especially the English and French. Formerly the Portuguese were the great fishers on these banks, and had their establishments on shore; but their fishery, like their commerce, fell with the decline of their naval power, and they are now content to buy their fish in their own ports, brought thither by ships belonging to foreigners. The Dutch have also for many years abandoned a fishery which they found less profitable than that nearer home. Indeed, so jealous were we once of the Dutch fishing on the Banks of Newfoundland, that Sir William Menson, in his treatise of the fishery, cautions the government to beware of letting them in; "for," says he, "they are like a serpent that never stings so deadly as when it bites without hissing." The French, by the treaty of 1763 with Great Britain, were limited in their fisheries to the neighbourhood of the small islands of St Pierre and Miquelon; and the Spaniards, by the same treaty, consented to abandon the Newfoundland fisheries altogether.

Since that time, however, a more formidable rival to the British fishery has started up in that of the Americans, who have latterly prosecuted the cod fishery with great vigour, and with advantages which the English, even with the possession of Newfoundland, are unable to command; owing, in a great degree, to the regulations by which this ancient possession of the British empire has till very lately been governed.

In a pamphlet entitled *Considerations on the Expediency of Adopting Certain Measures for the Encouragement or Extension of the Newfoundland Fishery*, supposed to have been written by the Secretary of Lord Gambier, when governor of that island, it is stated, that in the year 1805, the number of vessels employed in the American fishery amounted to about 1500, carrying about 10,000 men, and that the quantity of fish caught by them amounted to 800,000 or 900,000 quintals; whilst the whole produce of the British Newfoundland fishery of that year did not exceed 500,000 quintals, and that the number of vessels and men employed did not amount to one half of that employed by the Americans.

The causes assigned for this increasing success on the one hand, and falling off on the other, are as follow: The New England fishery, in all its branches, is carried on by shares, each man having a proportion of his own catch, and few or none being hired as servants on wages. By this mode the fisherman's interest being proportioned to his industry, he is prompted to labour by the most powerful incentive. The American fishermen are remarkable for their activity and enterprise, and not less so for their sobriety and frugality; and, in order to be as independent as possible of the owner of the vessel, each fisherman victuals himself, and the crew take it in turns to manage and cater for the rest. It is hardly necessary to add, that men, provisions, and every other article of outfit, are procured upon much better terms in the United States than in Great Britain. But the English fishermen must not only lay in a large stock of provisions out and home at a dear rate, but must also carry out with them a number of persons to assist in the fishery, who, consequently, eat the bread of idleness on the passage out and home; for the laws by which the colony was held were such as almost to forbid residency, and those who did reside had no power of internal legislation; they were restrained from erecting the necessary dwellings for themselves and their servants; they were prohibited from enclosing and cultivating the land, beyond the planting of a few potatoes; and from the importation of provisions from the United States, excepting only on such conditions as were not calculated to afford the residents much relief. "From a system," says the author of the pamphlet above mentioned, "the first object of which is to withhold that principle of internal legislation, which is acknowledged to be indispensable to the good government of every community, which restrains the building of comfortable dwellings in a climate exposed to the most inclement winter, which prohibits the cultivation of the soil for food, and restricts the importation of it from the only market to which the inhabitants have the power to go,—from such a system it is not surprising that the inhabitants of Newfoundland are not able to maintain a competition against the American fishermen."

During the late war, however, when France was completely driven out of her fisheries in the Gulf of St Lawrence, and the islands of St Pierre and Miquelon, the British and the resident fisheries about equalled, in the amount of fish taken, that of the Americans in the same quarter, who employed, in the year 1812, about 1500 vessels carrying each ten men, making, in the aggregate, the enormous number of 15,000 men employed in this branch of trade alone. The English merchants of London and Poole complain, and not without apparent good grounds, of the extraordinary privileges which America enjoyed at Newfoundland, in being permitted to cure and dry her fish on shore; which privileges, granted no doubt on an expectation that such a liberal proceeding would have paved the way to a reciprocal friendly conduct on her part, became a source of gross abuses and of unwarrantable claims. By the assembling together of numerous fleets, they interrupted the occupations of our residents; they destroyed their nets, enticed away their servants, smuggled into the colony coffee, tea, spirits, tobacco, India goods, and other articles of contraband, undersold the inhabitants in stores and provisions, and added insulting and abusive language to their manifold injuries.

Since the conclusion of the war, the United States have been re-admitted, by a convention, to all their former privileges of curing and drying their fish on the unsettled bays, harbours, and creeks of Nova Scotia, Labrador, and Newfoundland; but under certain modifications, which it is hoped will prevent those abuses that existed in a flagrant degree previously to the war. The Great Bank, owing to its distance from the shores of Newfoundland, is of course free to all the world; but the fishery can only be successfully carried on by a constant and uninterrupted communication with the shore, and the nearer to the shore that the fish are taken, the more advantageous is it to the fishermen. The Americans, being restrained from fishing within certain limits, and having the privilege of curing and drying their fish only at certain spots on the shore, labour under a comparative disadvantage with us in this respect, which serves to balance the advantage they possess over us in others. Under this convention, the fishermen of the United States are at liberty to take fish, in common with the subjects of his Britannic Majesty, on that part of the southern coast of Newfoundland which extends from Cape Ray to the Rameau Islands, from Cape Ray to the Quirpon Islands, on the shores of the Magdalen Islands, and also on the coasts, bays, harbours, and creeks, from Mount Joly, on the southern coast of Labrador, to and through the strait of Bellisle, and thence northerly indefinitely along the coast; and they are at liberty also to dry and cure fish in any of the unsettled bays, harbours, and creeks of the southern part of the coast of Newfoundland, and of the coast of Labrador; but as soon as the same, or any portion thereof, shall be *settled*, they are no longer at liberty to dry and cure fish at such portion, without a previous agreement with the inhabitants or proprietors; and, in consideration of these privileges, the United States renounce, on their part, any liberty heretofore enjoyed or claimed by their subjects, to take, dry, or cure fish, on or within *three marine miles* of any of the coasts, bays, creeks, or harbours of his Britannic Majesty's dominions in America, not included within the above-mentioned limits; but they may be admitted to such bays and harbours, for the purpose of wooding, watering, or repairing damages only. The merchants of Poole, and others concerned in the fishery, complain of this treaty; but it appears to be well calculated to prevent those disputes and abuses which before existed, and which would probably have interrupted the harmony so desirable to be preserved between the two nations.

The importance of the fisheries on the Banks of Newfoundland, on the coast of Labrador, in the Gulf of St Lawrence, and the neighbouring islands, may be conceived, from a memorial of the committee of merchants trading to Newfoundland, addressed, in 1814, to Lord Liverpool, in which it is stated that the catch of the French was generally estimated, at the least, at 300,000 quintals; that the Americans had reached, in 1811, nearly 1,000,000 quintals, besides fish-oil and other articles, the produce of the sea; and that the English fishery, during the American war, had increased to a degree equal to the most sanguine expectations; the export of dried cod alone, for the year 1813, having amounted to 946,102 quintals, which exceeded the shipment of the preceding year by nearly 300,000 quintals, or one third of the catch of the whole fishery, with a proportionate increase in cod-oil, seal-skins, seal-oil, salmon, &c. amounting in value to above L.1,500,000 sterling; employing in its transport to different markets at least 75,000 tons of British shipping, and 5000 seamen, independently of the persons actually employed in catching and curing the fish; and returning to England upwards of L.2,000,000 sterling.

These advantages, however, can scarcely be supposed to continue since the re-admission of the French and Americans, both of whom, it is to be feared, will be able to undersell our fishermen in the foreign markets; the former from a considerable bounty being given by government on the fish caught and cured on the Banks of Newfoundland, and the latter from their nearness to the fishing grounds, and cheapness of the outfit. It has indeed been questioned by political economists, whether it would not be more advantageous to the national interests, if the capital employed in the distant possession of Newfoundland, and the fisheries contiguous to it, were engaged wholly in the fishery on the banks of our own seas, and those of Iceland and the coast of Norway, which are so much nearer home. Newfoundland, however, in spite of all the restrictions imposed upon it, has risen into a colony of too much importance to be abandoned; and its growing prosperity depends so much (it may be said indeed solely) on the fishery, that the residents, with the assistance of America, will always be able to carry it on independently of England. Much of late has in fact been done to improve the condition of the colonists, and more will be required. Among other things, a resident governor has been appointed, so that the inhabitants are not left for a great portion of the year, as heretofore, to administer justice among themselves, which was usually done in his absence by a surrogate, with a salary of L.60 a year, and magistrates, whose occupations are in some way or other connected with the fishery.

The nature and value of the exports from Newfoundland will be seen by the following table:

mate of the Value of the Exports from Newfoundland between the 11*th of October* 1801 *and the* 10*th of October* 1802; *distinguishing the Countries to which they were sent, and the remittances proceeding therefrom to Great Britain.*

	Quantity		Destination	Rate	Value		Remitted to the United Kingdom, either directly, or through Foreign Europe.	
Fish..	318,396	Quintals to	Foreign Europe, at	25s. *per* Quintal,	L.397,995 0 0		L.397,995 0	
	60,230		British Europe	18s.	54,215 18 0		54,215 18	
	67,725		West Indies	18s.	60,952 10 0			
	14,784		United States	18s.	13,306 12 0			
	461,144							
Oil...	2,796	Tuns	British Europe	L.22 10 0 *per* Tun	62,910 0 0		62,910 0	
Salmo	4,033	Tierces	Various	72 6 6 Tierce	14,619 12 6	say one half to Gr. Britain..	7,309 16	
Seal S	36,000		Great Britain	4 0 0 each	7,200 0 0		7,200 0	
Furs.	value		Ditto		1,980 0 0		1,980 0	
				Total value at the Shipping Price in the Island...	L.613,179 12 6		L.531,610 14	
			Freight and Insurance.					
Fish..	318,396	Quintals to	Foreign Europe, at	L.0 3 0 *per* Quintal,	47,759 8 0		47,759 8	L.61,874. 11s. paid for freight on ships owned and fitted out in Gr. Brit., cleared out from Newfoundland for British and Foreign Europe, viz. Ships........228 Tons.....28,132 Men......1,775
	60,239		British Europe	0 1 6	4,517 18 0		4,517 18	
	67,725		West Indies	0 1 6	5,079 7 6			
	14,785		United States	0 1 6	739 4 0			
Oil...	2,796	Tuns	British Europe	5 5 0 *per* Tun	7,689 0 0		7,689 0	
Salmo	4,033	Tierces	Various	0 10 0 *per* Tierce	2,016 10 0	say one half to Gr. Britain	1,008 5	
Seal S	36,000		British Europe	0 0 0 say	900 0 0		900 0	
					L.681,881 0 6		L.593,485 5	
				Insurance, say 5 *per cent*	34,940 10 3		29,674 5	
				This sum may be assured as the lowest value at market,	L.716,821 10 9		L.623,159 10	
						Deduct the value of foreign salt, say 12,000 tons, at L.1 per ton	12,000 0	
				Lowes alue of Imports and Remittances from the Newfoundland Fishery to the United Kingdom in the year 1802			L.611,159 10	

But the following statement, taken from official documents, as the returns of the two years ending the 10th October 1814 and 1815, will show the advanced and advancing state of the fisheries of Newfoundland and of the colony.

In 1814.		In 1815.		Difference in one Year.
				Increase.
1. Number of fishing ships, European and island bankers, ships from Nova Scotia, &c. the West India and stationary vessels	892	Number of the same description	1,036	144
2. Burthen of the above-mentioned ships	107,998 tons.	Of the same	127,582	19,584
3. Number of men belonging to them	6,966	Number of the same	7,981	1,014
4. Number of boats kept by the fishing ships, bye-boatmen and inhabitants	3,241	Number of the same	3,518	277
5. Number of men employed in the fishery and trade in ships and boats, and as shoremen	19,295	Number of the same	22,167	2,872
6. Quintals of fish caught and cured by the fishing ships, bankers, and boats	865,132	The same	866,580	1,448
7. Exported to Spain, Portugal, and Italy, British Europe, the West Indies, British America, and the Brazils	947,811	The same	1,180,661	232,850
8. Tierces of salmon cured and sent to British and foreign markets	3,425	The same	3,752	327
9. Tuns of train oil made by the fishing ships	4,126	The same	4,298	172
10. The number of seal-skins taken	110,275	The same	121,182	11,007
11. Tuns of seal oil made	1,263	The same	1,397	134

The price of cod fish is, per quintal, from 15s. to 25s.; of salmon, from 65s. to 80s. the tierce; of train oil, from L.26 to L.34 the tun, and seal oil generally about L.36 the tun. In 1814 the number of passengers who went over from England, Ireland, and Jersey, amounted to 2800; in 1815 they were 6735. In 1814 the population of residents amounted to 35,952, and in 1815 to 40,568. In 1814 the summer inhabitants were 45,718, and in 1815 they were 55,284. The number of houses on the whole island was about 5000, and the number of acres under cultivation about 6000.

Northern whale fishery.

If we are to credit the information which Alfred is said to have received from Octer, the Norwegians were engaged in the whale fishery as early as the year 890. The story, however, is not very probable. The first people known to have carried it on as a regular occupation were the Biscayans, who, when the English first embarked in this fishery, towards the end of the sixteenth or beginning of the seventeenth century, were always engaged as part of the crew. It continued to be carried on by the Russian and the East India Company for some years, but with no great success, though sufficient to induce the Dutch to attempt it. After them came the Danes, the Hamburgers, and the French, all of whom were finally driven out, or nearly so, by the Dutch. At this time the whales were so plentiful in all the bays of Spitzbergen, that the practice then was to boil the oil on shore; but when, in process of time, these large fish became more scarce, or were scared from the shore, the fishery was carried on at a distance from the land, when it was found necessary to bring home the solid blubber in casks. This circumstance was a further discouragement to the English merchants, who, for more than a century, relinquished the whale fishery altogether. The South Sea Company, however, revived it in the early part of the eighteenth century, when parliament granted a bounty of 20s. per ton on all British ships of 200 tons and upwards, which was afterwards increased to 40s. per ton. This, however, by the 26th Geo. III. was again reduced to 30s.; but several encouragements were added for the prosecution of the whale fishery by able and expert seamen. The harpooners, the line-managers, and the boat-steerers, were not only protected from impress during the voyage, but were allowed to engage in the coal and coasting trade unmolested in the winter months, with other privileges granted by that and subsequent acts.

The decline of the Dutch whale fishery kept pace with the decline of their herring fishery, and, from the same cause, the decline of their maritime power, which had reciprocally supported each other. The English now began to carry on the fishery with great vigour on both sides of Greenland, so as to make it an object of great national importance, both as a nursery for excellent seamen, and as a source of public wealth. Upon the termination of the late war, the owners of ships employed in the northern whale fishery, alarmed by the apprehension of the Dutch and French reviving the fishery, but more so at the opening of the ports on the Continent, put forth a statement of the amount and extent of the fishery, from which it would appear that 7500 men and boys are employed in it as sailors; that, by act of parliament, the owners are required to take six apprentices for each ship of 300 tons, by which about 900 youths are constantly training for the future service of the country, and that about 200 of them complete the term of their servitude every year, when such as are not boat-steerers, harpooners, or line-managers, become liable to serve in the navy; that not less than 300 men are also taken annually from employments on land, or from the river trade, most of whom, after two years, are competent to serve in his majesty's navy; who, with the apprentices and unprotected seamen employed, make a total of 4000 effective men subject to impressment.

It is further stated by the owners, that at the termination of the war, no less than 148 valuable ships, comprising 50,000 tons, and engaging a capital of L.2,000,000, were employed in the Greenland and Davis' Straits fishery; that the provisions for the voyage amount to about L.600 for each ship, forming a total of L.90,000, wholly furnished from our own markets, affording encouragement to agriculture, as well as to the various descriptions of tradesmen through whose hands the provisions are supplied; that the whole produce, therefore, of the fishery may be considered as gain to the country.

As, however, foreign ships may be sent to the fishery on more moderate terms than the English can supply theirs, and as the king of the Netherlands has offered considerable bounties to ships proceeding to the northern fisheries, all hope appears to be cut off that Englishmen will ever be again permitted to contribute to the supply of foreign markets with whale oil, but must in future look to the consumption of Great Britain alone. It is therefore suggested by the shipowners as some relief, that the enormous quantity of foreign rape-seed, which has recently been imported into this country nearly duty-free, should be checked; and that, by laying a sufficient duty on the importation of this article, the protection of government would be beneficially extended at once to the encouragement of the British agriculturist and the relief of the Greenland trader. No reasonable objection, it is stated, can be made to such a measure, unless from a mistaken apprehension with regard to its effects on the price of woollen cloths, which is so inconsiderable that a duty of L.12 per last on foreign rape-seed would not occasion an advance of more than about one farthing and a half per yard on narrow cloths; and that in fine cloths Gallipol oil alone is used. This appears to be reasonable enough; but the owners of the whale-fishing ships had another and a more formidable rival in the market in the lighting of the streets of London and other great towns with gas. It was stated, that for every three parishes in the metropolis thus lighted, five whole ships would be thrown out of employment; and that if all the parishes in London, Westminster, and Southwark, should be so lighted, it must entirely put an end to a trade which employs 10,000 seamen, 2000 apprentices, and 2000 landsmen, training constantly to the sea, and which affords occupation to about 100,000 individuals. The Gas Company say, on the other hand, that the expenditure of coal will amply compensate, in a national point of view, for any loss the Greenland trade may sustain, by the additional quantity of shipping employed in bringing the coal to the metropolis. This, however, is an exaggerated statement; but as whale-oil is now employed for so many more purposes than formerly, and even in the manufacture of gas, the lighting of the streets, even if general, will probably not injure the fishery to any great extent; though the lighting of the shops and private houses, should the practice become general, must seriously injure the South Sea fishery, as sperm was very commonly used for domestic purposes.

The state of the northern whale fishery will be seen from the following account of the number of fish and produce of oil brought by the ships of the several ports of Great Britain from the Greenland and Davis' Straits fishery, in the year 1814:

Ships.		Fish.	Oil.
58	Hull	697	7326
20	London	367	2981
1	Lynn	25	187
1	Grimsby	7	85
8	Whitby	172	1381
5	Newcastle	49	628
2	Berwick	16	178
10	Leith	73	1021
1	Kirkaldy	7	100
8	Dundee	61	955
3	Montrose	47	306
2	Liverpool	43	437
13	Aberdeen	178	1733
7	Peterhead	164	1390
2	Banff	30	245
1	Kirkwall	10	120
1	Greenock	35	245
143	Total	1981	19,408

143 ships, at 50 men to each ship, give 7150 as the number of men employed annually in the northern whale fishery.

19,408 Tuns of oil, at L.38	L 737,504	0	0
647 Ditto whale-bone, the produce of 1981 fish, at L.80 per ton	51,760	0	0
Total amount of the produce of the northern whale fishery in the year 1814	L.789,264	0	0

The statutes of 35 Geo. III. c. 92, and 42 Geo. III. c. 18, regulate the proceedings, and prescribe the conditions on which premiums of L.100 to L.400 may be claimed by each of sixteen ships employed in this fishery. Though less important, in a national point of view, than the northern whale fishery, the number of ships and seamen employed in it are very considerable. They are fitted out mostly from London, and amounted, in the year 1815, to 107 ships, comprising 32,100 tons, and manned with about 3210 seamen, and their return cargoes were calculated to be worth about L.1,070,000 sterling.

The returns of the two fisheries, then, will stand thus:

	Ships.	Men.	Value.
In the northern fishery	143	7150	L.789,264
In the southern ditto	107	3210	1,070,000
Total	250	10,360	L.1,859,264

These statements of the productive value of the foreign British fisheries may probably approach pretty nearly to the truth; but the reports of the home fisheries are too vague to afford any thing like an accurate estimate. If we should take the 120,000 tons of fish said to be imported annually into the metropolis, at the low average rate of threepence a pound, and allow for the rest of the consumption in the British empire only one half the quantity consumed in and exported from the capital, and half a million for the export produce of the herring and cod and ling fishery, we shall have the productive value of the whole as under:

The Greenland and South Sea fisheries	L.1,800,000
The Newfoundland fishery	1,500,000
The herring, cod, and ling ditto for exportation	500,000
The consumption of London and re-exportation	3,000,000
Ditto of the rest of Great Britain	1,500,000
	L.8,300,000

As to the number of seamen, landmen, and boys employed in the fisheries, that is, *on the water*, they may be reckoned at about 120,000.

Pearl Fishery. See *Pearl*, MOLLUSCA, *Index*.

Whale Fishery. See *Balæna*, MAMMALIA, *Index*.

FISHGUARD, a market-town of Pembrokeshire, in South Wales, within the hundred of Komyss, 151 miles from London. It is situated on the shore, at the spot where the river Gwaine falls into the sea. It is governed by a mayor and corporate body. The trade is but trifling, but there is a well-supplied market on Friday. A corps of 1200 French troops, composed chiefly of enlisted felons, landed here in 1797, but were speedily made prisoners by the local volunteers. The population in 1801 amounted to 1503, in 1811 to 1572, in 1821 to 1837, and in 1831 to 1990.

FISHING, in general, is the art of catching fish, whether by means of nets, spears, or the line and hook. See ANGLING and FISHERIES.

FISSURES, in *Geology*, certain interruptions, which divide the several strata of which the body of our globe is composed, in a horizontal or parallel manner.

Fissure of the Bones, in *Surgery*, is when they are divided either transversely or longitudinally, not quite through, but cracked like glass, by any external force.

FISTULA, in the ancient music, a wind instrument resembling our flute or flageolet.

The principal wind instruments of the ancients were the *tibia* and the *fistula*. But how they were constituted, in what they differed, or how they were played upon, does not appear; indeed all that we know is, that the *fistula* was at first made of reeds, and afterwards of other matters. Some had holes, others none; some again were single pipes, others a combination of these; as, for instance, the *syringa* of Pan.

FISTULA, in *Surgery*, a deep, narrow, and callous ulcer, arising generally from abscesses. It differs from *sinus* in being callous, which the latter is not.

FITCHES, in *Husbandry*, a sort of pulse, more generally known by the name of *chick-pea*. Fitches are cultivated either for the purpose of feeding cattle or improving the land. They are a wholesome and nourishing food, whether given in the straw or thrashed out. When sown only to improve the soil, they are ploughed in just as they begin to blossom, by which means a tough clay soil is much enriched.

FITCHET, a name used in some places for the weasel, which is also called the *foumart*.

FITCHY, in *Heraldry* (from the French *fiehé*, fixed), a term applied to a cross when the lower branch ends in a sharp point. The origin of this device is supposed to be, that the primitive Christians were accustomed to carry about crosses with them wherever they went; and when they stopped at any place on a journey, they fixed these portable crosses in the ground for the sake of devotion.

FITERO, a town of Spain, in the province of Navarre. It is situated on the banks of the Alhama, which, though a river of short course, is highly beneficial, by its irrigating capabilities, to the country through which it passes. The monastery of Fitero is very richly endowed; and the town, which contains 3500 inhabitants, as well as the land around it, is the property of that establishment. The whole of the people are employed in the cultivation of hemp, and in the consequent manufactures of that article. There are some warm mineral springs, which are resorted to for the cure of several complaints, and which attain to the heat of thirty-six degrees Reaumur.

FITZHERBERT, SIR ANTHONY, a learned lawyer in the reign of Henry VIII. was descended from an ancient family, and born at Norbury in Derbyshire, but in what year is not known. After receiving the rudiments of his education in the country, he was sent to Oxford, on leaving which he entered himself in one of the inns of court, and appears in due time to have been called to the bar. By talents and diligence, united with judgment, he soon distinguished himself in his profession, and in 1511 he became a serjeant at law. In 1516 he received the honour of knighthood, and the year after was made one of the king's counsel. And in 1523 he was raised to the bench as a puisne judge of the court of common pleas, in which honourable station he spent the remainder of his life. Fitzherbert was deservedly respected for his ability and integrity as a judge; and, at a time when judicial independence was a rare virtue on the bench, he opposed the court in some of its favourite projects, particularly regarding the alienation of church lands. He died on the 27th of May 1538, and was buried in the parish church of Norbury, the place of his birth. The works of this learned lawyer are, 1. The Grand Abridgment collected by that most reverend judge Mr Anthony Fitzherbert, lately conferred with his own manuscript corrected by himself, together with the references of the cases to the books, by which they may be easily found, printed in folio by Rynson in 1514, by Wynken de Worde in 1516, and again in 1577; 2. The Office and Authority of Justices of Peace, 1538, but often reprinted, the last edition being dated 1617; 3. The Office of Sheriffs, Bailiffs of Liberties, Escheators, Constables, Coroners, and others, 1538; 4. Of the Diversity of Courts, 1529; 5. The New *Natura Brevium*, 1534, to which, in the last edition, published in 1794, 2 vols. 8vo, is added a commentary supposed to have been written by Chief-Justice Hale, with notes, references, and an enlarged index; 6. Of the Surveying of Lands, 1539; 7. The Book of Husbandry, 1534, reprinted several times in the reigns of Mary and Elizabeth. Of these works, five, in the order in which they are here enumerated, were, with the exception of part of the second, originally written in French.

FITZSTEPHEN, William, an English monastic historian of the twelfth century, and author of the earliest description extant of London, was of Norman extraction, but born of respectable parents in the city of London. Being a monk of Canterbury, he attracted the notice of Archbishop Becket, who made him one of his clerks, received him as an inmate into his family, and employed him in various capacities. He was remembrancer in the archbishop's exchequer, a subdeacon in his chapel when he officiated, a reader of bills and petitions when his grace sat to hear and determine causes, and sometimes an advocate before the ecclesiastical court, when he was desired to perform that office. He was also present with Becket at Northampton, when the archbishop was forsaken by his suffragans, and an eye-witness of his sacrilegious murder at Canterbury, one of the foulest deeds of an age fertile in crimes. This worthy monk is supposed to have died in the year 1191. His *Description of the City of London*, which seems to have been written between the years 1170 and 1182, contains, after Doomsday-Book, the earliest account we have of the metropolis; and it may be doubted whether any other nation of Europe can produce a description of its capital, or of one of its principal cities, written at so remote a period as the twelfth century. The first edition appeared in the shape of a translation inserted in Stowe's *Survey of London*; but as this was found to be in many respects inaccurate, and had, besides, become obsolete, Dr Pegge published a more correct translation, with notes and a preliminary dissertation, 1772, in 4to. Fitzstephen was a person of great learning for his age. He appears to have been tolerably versed in Horace, Virgil, Sallust, Ovid, Lucan, Persius, and other Latin classics; and he had even looked into Plato and some other of the Greek writers. His credulity was a failing less imputable to the individual than to the times in which he lived.

FIUME, a circle in the Austrian province of Trieste, extending over 1364 square miles, containing thirty-four cities and towns, and 193 villages, with 24,930 houses, and 131,484 inhabitants. The principal products are wine, olives, fruit, and silk. The capital is a sea-port situated on the Gulf of Quarnaro. It consists of two long parallel streets on the shore, and others connecting them, and contains 743 houses and 7576 inhabitants, chiefly employed in fishing or in trade, which consists in the productions of the surrounding district. The harbour is good, and the situation as favourable for the trade with Hungary as Trieste is for that of the other Austrian states. Long. 14. 20. 10. E. Lat. 45. 20. 16. N.

FIXATION, in *Chemistry*, the rendering of any volatile substance fixed, so as not to fly off or evaporate upon being exposed to a great heat.

FIXED BODIES are those which sustain a considerable degree of heat without evaporating, or losing any of their weight. Some of the most fixed bodies are diamonds, gold, &c.

FIXITY, or Fixedness, in *Chemistry*, is in a peculiar manner used for the affection opposite to volatility; in other words, it is the property by which bodies sustain the action of the fire, without being dissipated in fumes.

FIXLMILLNER, Placidus, a learned astronomer, was born at Achleuthen, near Linz, in Austria, on the 28th of May 1721. He received the rudiments of his education in the monastery of Kremsmunster, of which his uncle Alexander was abbot; afterwards went to Salzburg, where he studied a regular course of philosophy, but turned his attention particularly to the mathematics. In 1737, he was admitted as a novice into the Benedictine monastery, Kremsmunster, and the next year he took the solemn vow in presence of the abbot. After being two years in this monastery, during which time he devoted every leisure hour to the study of mathematics and philosophy, he returned to Salzburg to finish his studies in theology and jurisprudence, and at the same time acquired a competent knowledge of the oriental and modern languages, besides history and antiquities. In 1745, he obtained the degree of doctor in divinity, after which he received priest's orders in his own monastery, and was created professor of ecclesiastical law, which office he held during forty years, discharging its duties until within a few days of his death. He was also chosen as dean of the higher schools, and regent of the young nobility, offices which he retained during his life.

Fixlmillner wrote a commentary on the *Jus Canonicum*, but this work was never published. By the entreaties of his friends, he was induced to publish his *Reipublicæ sacræ Origines divinæ, seu Ecclesiæ Christi exterior junctura, imperium, et hierarchia, ex primigenia ejus institutione eruta et demonstrata*. But it was his knowledge of astronomy which rendered him truly illustrious. His uncle Alexander fitted up an apartment for containing the instruments necessary for the pursuit of mathematical knowledge; and he also erected an observatory, which was begun in 1748, and completed in 1758, under the direction of Anselm Dering of Emsdorf, a celebrated architect. Whilst the observatory was building, Fixlmillner led a life of retirement and severe study, his favourite pursuit during this time being astronomy. When the edifice was finished, Dobler, a mathematician of some note, was appointed first astronomer; but the successors of his uncle the abbot having discovered Fixlmillner's extensive mathematical knowledge, made him an offer of the astronomical department, and the sole direction of the observatory; and this place he accepted in the year 1762, at the same time retaining his chair as professor of ecclesiastical law. He was not yet master of the learning which practical astronomy requires; but to remedy this defect he perused attentively Lalande's *Exposition du Calcul Astronomique*, soon after which he obtained the large astronomical work of the same author, and in 1766 published his *Meridianus Speculæ Astronomicæ Cremifanensis*, Steyer, 4to, by which he acquired considerable reputation. Ten years after this period he gave the world his *Decennium Astronomicum*, Steyer, 4to, containing many curious and important particulars respecting the theory and practice of astronomy. His *Acta Astronomica Cremifanensia*, Steyer, 1791, 4to, which did not appear till after his decease, still further increased his astronomical reputation; and he was, besides, a large contributor to many periodical publications in different countries.

He made and collected a great number of observations on the planet Mercury, the importance of which was publicly acknowledged by Lalande, as they greatly assisted him in constructing his tables of that planet. Fixlmillner was one of the first astronomers who calculated the orbit of the new planet Uranus (*Georgium Sidus*), his tables respecting which will be found in the Berlin Almanack for 1789. He also proved the truth of what had formerly been conjectured, that the thirty-fourth star of Taurus, which Flamsteed observed in 1690, was the new planet. It may be said of most philosophers, that they observe a great deal and calculate little; but the conduct of Fixlmillner was exactly the reverse. He turned his attention more than any of his predecessors to the solar spots, which he observed in the years 1767, 1776, 1777, 1778, and 1782, and from which he deduced important inferences respecting the revolution of the sun on his axis.

Fixlmillner had a genius singularly adapted for the study of mechanics, by which he was enabled to invent a new micrometer, and a machine for grinding concentric circles. As he resided in the country, he was in a great measure deprived of literary assistance; but his indefatigable zeal, diligence, and perseverance more than supplied the want of such aid. He was but little subject to the influence of the stronger passions. Like the laws of nature, which it was his chief delight to study, he was simple, uniform, and constant; and by the mildness and integrity of his character, he acquired the love and esteem of mankind. His high reputation never inspired him with vanity, and he rather wished to conceal than to propagate what had been written in his praise. His health having been very much impaired by his intense application, he terminated his earthly career on the 27th August 1791, in the seventy-first year of his age.

FLACCUS, Caius Valerius, an ancient Latin poet, of whom personally but little is known. He is supposed to have been born at *Setia*, a town of Campania, now Sezzo, whence he has derived the surname of Setinus. But Martial, his contemporary and friend, seems to intimate that he was a native of Padua, or at least lived there. He died when he was about thirty years of age, in the year 93 or 94 of our era, before he had put the finishing hand to the poem on which his reputation entirely rests. The subject which he selected as deserving of celebration was the history of the Argonautic expedition; but of the ten books into which he intended to divide it, he lived only to compose seven and part of the eighth. This poem, which is addressed to the emperor Vespasian, whom the poet compliments on account of his conquest of Judæa, whilst Domitian is at the same time praised for his poetical talents, is an imitation rather than a translation of the Argonautics of Apollonius; and Flaccus has evidently been most successful in those parts where he had not the Greek poet immediately in his view. The model upon which he formed himself was Virgil; and, notwithstanding Horace's sneer at the *servum pecus*, it is surprising how closely the imitator sometimes approaches to the great original. Quintilian's opinion of his merit may be easily gathered from the brief but expressive eulogium, *Multum in Valerio Flacco nuper amisimus.* The best editions of this poet are that of Nicolas Heinsius, published at Amsterdam, 1680, in 8vo, reprinted of the same size in 1702; and that *cum notis integris variorum et Petri Burmanni*, which appeared at Leyden, 1724, in 4to. It is proper to add, that Baptista Pius, an Italian poet, completed the eighth book of the *Argonautics*, which Flaccus had left unfinished, and added two more from Apollonius; a supplement which was first printed by Aldus in 1523, and which has been subjoined to most, if not all, of the subsequent editions. (Vossius *de Poet. Lat.*; Fabricius, *Bibl. Lat.*; and Moreri.)

FLAGS, in the army, are small banners of distinction stuck in the baggage waggons, to distinguish the baggage of one brigade or battalion from that of another, in order that they may be marshalled by the waggon-master-general, so as to avoid the confusion that might otherwise ensue.

Flag, in nautical affairs, a banner or standard, by which an admiral is distinguished at sea; also the colours by which one nation is distinguished from another.

In the British navy flags are either red, white, or blue, and are displayed from the top of the main-mast, fore-mast, or mizen-mast, according to the rank of the admiral. When a flag is displayed from the staff on the main-mast, the officer distinguished thereby is known to be an admiral; when from the fore-mast, a vice-admiral; and when from the mizen-mast, a rear-admiral.

The first flag in Great Britain is the royal standard, which is only to be hoisted when the king or queen is on board the vessel; the second is that of the anchor of hope, which characterizes the lord high admiral, or lords commissioners of the admiralty; and the third is the union flag, in which the crosses of St George and St Andrew are blended together. This last is appropriated to the admiral of the fleet, who is the first naval officer under the lord high admiral.

The next flag after the union is that of the white squadron at the main-mast head; and the last which characterizes an admiral is the blue, also at the main-mast head. For a vice-admiral, the first flag is the red, the second the white, the third the blue, at the flag-staff on the fore-mast. The same order proceeds with regard to the rear-admirals, whose flags are hoisted on the top of the mizen-mast. The lowest flag in our navy is accordingly the blue on the mizen-mast.

To Lower or Strike the Flag, in the navy, is to pull it down upon the cap, or to take it in, as a token of the respect due from all ships or fleets to those which are undeniably their superiors. To lower or strike the flag in an engagement is a sign of submission or surrender.

The method of leading a ship in triumph is to attach the flags to the shrouds, or the gallery, in the hind part of the ship, letting them hang down towards the water, and to tow the vessels by the stern. Livy relates that this was the mode in which the Romans used those of Carthage.

To Heave out the Flag, is to display or put abroad the flag.

To Hang out the White Flag, is to ask quarter; or, when a vessel has arrived on a coast, it shows that it has no hostile intention, but comes to trade, or the like. The red flag is a sign of defiance and battle.

Flag-Officers are those who command the several squadrons of a fleet; such as the admirals, vice-admirals, and rear-admirals. The flag-officers in our pay are the admiral, vice-admiral, and rear-admiral, of the white, red, and blue. See Navy.

FLAGELLANTES, a set of wild fanatics who chastised and disciplined themselves in public by means of the lash. The sect of the Flagellantes took its rise in Italy in the year 1260; its author was one Rainier, a hermit, and it was thence propagated throughout almost all the countries of Europe. The formation of this sect was in all probability merely the effect of an indiscreet zeal. A great number of persons of all ages and sexes made processions, walking two by two with their shoulders bare, which they whipped till the blood ran down, in order to obtain mercy from God, and appease his indignation against the wickedness of the age. They were then called *the devout*; and having established a superior, he was called *the general of the devotion*. Though the primitive Flagellantes were exemplary in point of morals, yet they were joined by a turbulent rabble infected with the most ridiculous and impious opinions, and both the emperors and pontiffs felt themselves called upon to put an end to this religious frenzy, by declaring all devout whipping contrary to the divine law, and prejudicial to the eternal rest of the soul.

This sect was revived in Germany towards the middle of the next century, and, rambling through many provinces, occasioned great disturbances. They held, amongst other absurdities, that flagellation was of equal virtue with baptism and the sacraments; that by means of it the forgiveness of all sins was to be obtained from God without the merits of Jesus Christ; and that the old law of Christ was soon to be abolished, and a new law enjoining the baptism of blood, to be administered by whipping, was to be substituted in its stead. By an injudicious as well as unrighteous policy, Clement VII. thundered out anathemas against the Flagellantes, who were consequently burnt by the inquisitors in several places; but they were not to be easily extirpated. They appeared again in Thuringia and Lower Saxony in the fifteenth century; and rejecting not only the sacraments, but every branch of external worship, placed their only hopes of salvation in faith and flagellation, to which they added other strange doctrines concerning evil spirits. Their leader Conrad Schmidt and many others were very needlessly committed to the flames by German inquisitors about the year 1414.

FLAGEOLET, or FLAJEOLET, a little flute, made of box or other hard wood, and sometimes of ivory, and having six holes besides that at the bottom, the mouth-piece, and the one behind the neck.

FLAIL, an instrument for thrashing corn, consisting, first, of the hand-staff, or piece held in the thrasher's hand; secondly, of the swiple, or that part which strikes out the corn; thirdly, of the caplins, or strong double leathers, made fast to the tops of the hand-staff and swiple; and, fourthly, of the middle band, being the leather thong or fish skin that ties the caplins together.

FLAIR, in nautical language, to incline or hang over. Seamen say that the work flairs over when a ship is housed in near the water, so that the work hangs over a little too much, and is let out broader aloft than is warranted by the due proportion.

FLAMBEAU, a kind of torch made of several thick wicks, covered with wax, and serving to burn at nights in the streets, as also at funeral processions, illuminations, and such like occasions. Flambeaux differ from links, torches, and tapers, in being made square, sometimes of white wax and sometimes of yellow. They usually consist of four wicks or branches about an inch in thickness and three feet in length, made of a sort of coarse hempen yarn half twisted. They are prepared with the ladle, in much the same way as torches or tapers, by pouring the melted wax on the top of the several suspended wicks, and letting it run down to the bottom; an operation which is repeated till the requisite thickness be obtained. After each wick has thus got its proper cover of wax, they are laid out to dry, then rolled on a table, and four of them joined together by means of a red-hot iron. When united, more wax is poured on, until the flambeau is brought to the size required, which is usually from a pound and a half to three pounds. The last thing is to finish their form or outside, which is done with a kind of polishing instrument of wood, by running it along all the angles formed by the union of the branches.

The flambeaux of the ancients were different from ours, having been made of woods dried in furnaces or otherwise. Various kinds of wood were used for this purpose, but that most commonly employed was pine. Pliny says, that in his time oak, elm, and hazel were also frequently used. In the seventh book of the Æneid mention is made of a flambeau of pine; and Servius remarks that flambeaux were also made of the cornel-tree.

FLAMBOROUGH HEAD, a cape or promontory on the eastern coast of Yorkshire, five miles east of Burlington, and 215 from London. This was the *Fleamburg* of the Saxons, having, it is supposed, been so called from the lights made on it to direct the landing of Ina, who, in 547, joined his countrymen in these parts with a large reinforcement from Germany, and founded the kingdom of Northumberland. In the time of Edward the Confessor, Flamborough was one of the manors of Harold, earl of the West Saxons, afterwards king of England; but on his death the conqueror gave it to Hugh Lupus, who bestowed it on the monastery of Whitby. The town is situated on the north side, and consists of about 150 small houses, entirely inhabited by fishermen, few of whom, as is said, die in their beds, but meet their fate in the element with which they are so conversant. The cliffs of the Head are of a tremendous height and amazing grandeur. Beneath are several vast caverns; some closed at the end, others pervious, and all formed with a natural arch. In some places the rocks are insulated, and of a pyramidal figure, soaring up to a vast height. The bases of most are solid, but in some instances they are pierced through and arched. The colour of all these rocks is white, from the dung of the innumerable flocks of migratory birds, which quite cover the face of them. Long. 20. E. Lat. 54. 15. N.

FLAME is a general name for every kind of luminous vapour, provided the light it emits has any considerable degree of intensity. Flame, however, is most generally applied to such as are of a conical figure, like those arising from our common fires; the others are commonly called *luminous vapours*, or *simple lights*. See HEAT.

Flames are of different colours, according to the substances from which they are produced. Thus, the flame of sulphur and spirit of wine is blue; the flame of nitre and zinc, of a bright white; that of copper, of a greenish blue, and so on. These varieties afford an opportunity of making a number of agreeable representations in fireworks, which could not be accomplished if the flame produced from every different substance was of the same colour. See PYROTECHNICS.

FLAMEN, in Roman antiquity, the name of an order of priests, instituted either by Romulus or Numa, authors not being agreed which of the two was its founder.

They were originally only three; the *Flamen Dialis*, *Flamen Martialis*, and *Flamen Quirinalis*. The *Flamen Dialis* was sacred to Jupiter, and a person of the highest consequence and authority in the state. He discharged several religious duties which properly belonged to the kings, and was honoured with many eminent privileges, but was obliged to observe several superstitious restraints. The *Flamen Martialis* was sacred to Mars, and was ordained to inspect the rites of that warlike god. The *Flamen Quirinalis* was sacred to and superintended the rites of Romulus Quirinus. But the Flamines last mentioned, though of high authority, were much inferior to the *Flamen Dialis*; and all three were chosen by the people, and consecrated by the *Pontifex Maximus*. In latter times several priests of the same order and name were added to their number, but inferior in power. The whole at last amounted to fifteen, the first three of whom were senators, and called *Flamines Majores*; whilst the other twelve, taken from among the people, were denominated *Flamines Minores*. According to some authors, the Romans had a Flamen for every deity they worshipped. The greater Flamines wore the robe edged with purple, like the great magistrates, and had an ivory chair, with a seat in the senate. They also had a little band of thread about their heads, and hence their name, *quasi Filamines*, is said to have been derived. The wife of the *Flamen Dialis* was called *Flaminica*, and wore a flame-coloured habit, on which was painted a thunderbolt, whilst above her head-dress she had green oak boughs, to indicate that she belonged to Jupiter the thunderer, to whom the oak was sacred. The Flamines wore each of them a hat or cap called *Flammeum* or *Apex*.

FLAMINIA VIA, an ancient Roman road, constructed by C. Flaminius, during his censorship, 220 B. C. Proceeding from Rome through Etruria in a direct line to Narnia, now *Narni*, in Umbria, it was divided into two branches, the one to the east leading through *Terni* and *Spoleto* to *Foligno*, where it met the other, which passed through *Careoli* and *Bevagna*. It then continued its course to Nuceria, where it again branched off in two directions, the one passing through the district of *Picenum* to Ancona, and along the coast of the Adriatic to *Fanum Fortunæ*, *Fano*, where it met the other, which followed the more direct line of *Intercisa* or *Furlo*, and *Forum Sempronii* or *Fossombrone*. It did not go beyond *Ariminum*. (Bergier, *Hist. des Grands Chemins.*)

FLAMINIUS, C., a Roman senator, one of the most distinguished men of his family, the chief transactions of whose life are comprehended between his tribuneship, 232, and death, 217, B. C. He was one of the most powerful supporters of the liberal party in Rome, and was amongst the first to suggest the idea of dividing the land taken from the *Galli Senones*, in *Picenum*, amongst the lower orders; a suggestion which proved ever afterwards a source of irritation between the aristocracy and plebeians. This proposal made him, of course, the favourite of the people, and detested by the senate, who lost no opportunity of mortifying and thwarting the plans of Flaminius as far as they could do so with safety to themselves. By his influence with the people he was raised to the consulship (223 B. C.), and proceeded with his colleague Furius to conduct the war against the *Galli Insubres*, a powerful tribe in Cisalpine Gaul, to the north of the Po, whose capital was Milan. They had scarcely arrived, when the senate, who had it always in their power to punish a magistrate whose conduct they disapproved, by pretended flaws in the election, or by sacrifices not duly performed, sent an order for their immediate return. The friends of Flaminius had advertised him of the contents of the dispatch, and he, resolving not to be baffled in his object, deposited it quietly in his portfolio, under pretence that he was too much occupied with his military manœuvres to have time to attend to the civil affairs of Rome. But when he had struck a decisive blow against the enemy, and thus justified the support given by his friends at Rome, he opened the dispatch, and found that it contained his recal. He felt himself, however, too powerful in the affections of the people to care for the spleen of the senate, and boldly set it at defiance, by remaining in the north of Italy till he had made a satisfactory arrangement of this part of the country. On his return he was degraded by the senate, but the people indemnified their favourite by voting him a triumph.

Flaminius continued to support every measure calculated to increase the power of the people, or to diminish that of their opponents. He procured the enactment of a law, that no senator should possess a ship of larger burden than was sufficient to contain three hundred amphoræ, equal to about 900 English bushels. This increased still more his influence with the people, and he was again elected consul (217 B. C.), though absent at *Ariminum*, to which place he had retired to await the result of the election. He was fearful that the senate would manage to retain him in the city, by falsifying the auspices or delaying the celebration of the *Feriæ Latinæ*. They attempted to recal him, but he disregarded their commands, and took his station at *Arretium*, now *Arrezzo*, to wait the arrival of Hannibal. But that artful general drew the army of Flaminius into the ambuscade he had laid on the Thrasymene Lake, and the result was the complete defeat of the army and death of Flaminius. (Polyb. ii. 21, 32, 33; Cic. *Acad.* iv. 5; Liv. xxi. xxii.)

Flaminius, *T. Quinctius*, an illustrious Roman senator, born about 228 B. C., at a time when his country was engaged in important wars, which drew forth all the talent it possessed. His early youth was passed in arms against Hannibal; and so much did he distinguish himself in the various duties he was called on to discharge, that he ventured to stand candidate for the consulate before the legal age, and without having passed through the inferior offices. His canvass was successful, and he became consul at the age of thirty (198 B. C.). The Romans had for several years been engaged in a contest with Philip III. king of Macedon, whose supremacy extended over the whole of Greece; and he had as yet baffled all attempts made by them to bring him under subjection. The war with this monarch was entrusted to the young Flaminius; and by the wisdom and vigour of his measures he compelled Philip to retreat from a strong position on the river Apsus in Epirus, where he had hitherto been able to set the Roman generals at defiance. This opened up to him the road to Thessaly, where he had no sooner arrived than the whole country declared itself in his favour. The mildness of his manners, his affability, and constant regard to the strict rules of justice, gained him the hearts of all who approached him; but Philip was determined not to yield the power which he had inherited from his ancestors without a struggle. The armies met at Cynoscephalæ in Thessaly, to the south of the river Peneus, small hills so called from their resemblance to the heads of dogs; and the result was the entire defeat of Philip (197 B. C.). Though that monarch was entirely in his power, Flaminius restored to him his kingdom, but compelled him to renounce all claim to the sovereignty of Greece. He prevailed on the commissioners, who had been sent by the senate to assist him in settling the affairs of Greece, to declare its entire independence, and to withdraw the garrisons from all its cities. The wisdom of this policy was soon effectually proved; as Greece became more completely attached to the Roman dominion from affection than she could ever have been by force. In the latter years of his life we find him employed in a mission to which, from his noble character and humane disposition, we can scarcely give credit. He was sent (183 B. C.) by the senate to demand from Prusias king of Bithynia, that Hannibal should be given up to the Romans; and though Prusias used every intercession in favour of a man who lived with him under the sanction of hospitality, he could not prevail. Flaminius, it seems, insisted that his demand should be granted; and, to escape his enemies, Hannibal put an end to his life by poison. Plutarch states that there is some doubt whether Flaminius was employed in this embassy; and we would fain believe that he did not tarnish his character by conduct so utterly unworthy of it. (Plutarch, *Life of Flaminius*; Livy, xxxii. xxxiii. xxxiv.)

FLAMSTED, a village and parish of England, in the county of Hertford, anciently called Verlamstedt, from its vicinity to the river. The population amounted in 1831 to 1462.

FLAMSTEED, John, an eminent English astronomer, and the first who obtained the appointment of astronomer-royal, was born at Derby in the year 1646. He was educated at the free school of Derby, where he was head scholar at fourteen years of age, at which period his constitution, naturally delicate, sustained a severe trial by an attack of illness. When some of his companions went to the university, the state of his health prevented him from accompanying them. He afterwards met with a treatise *De Sphæra*, by Sacrobosco, a work which, being perfectly suited to the natural turn of his genius, he perused with uncommon satisfaction, translating as much of it into English as he thought could be necessary for him; and from the *Astronomia Carolinæ* of Street he learned the method of calculating eclipses, and ascertaining the places of the planets. Mr Hatton, a mathematician, sent him Kepler's *Tabulæ Rudolphinæ*, and Riccioli's *Almagestum Novum*, together with some other astronomical works to which he was as yet a stranger. In 1669 he calculated an eclipse of the sun, which had been omitted in the Ephemerides, together with five appulses of the moon to fixed stars, and sent them to Lord Brouncker, then president of the Royal Society, who submitted them to the examination of that learned body, by whom they were greatly applauded, and Flamsteed received letters of thanks from Mr Oldenburg the secretary, and from Mr John Collins, one of the members. In 1670, being invited by his father to come up to London, in order that he might become personally acquainted with his learned correspondents, he gladly accepted the invitation, and had an interview with Mr Oldenburg and Mr Collins, by the latter of whom he was introduced to Sir Jonas Moore, who became his warm friend and patron. In consequence of this journey he became acquainted with many astronomical instruments, and was presented with Townley's micrometer by Sir Jonas Moore, who also assisted him in procuring glasses at a moderate rate for the construction of telescopes. On his way home he paid a visit to Dr Barrow and Mr, afterwards Sir Isaac Newton, at Cambridge, and entered himself as a student of Jesus College.

In the year 1672, he made large extracts from the letters of Gascoigne and Crabtree, by which his knowledge of dioptrics was much improved; and during the same year he made a number of celestial observations when the weather would permit, which were afterwards published in the *Philosophical Transactions*. In 1673 he composed a treatise on the true and apparent diameters of the planets, when at their greatest and least distances from the earth; a work from which even Newton himself did not scruple to borrow, and of which he made some use in his *Principia* in 1685. In 1674, Flamsteed published an Ephemeris, in which he exposed the folly and absurdity of astrology; and the same year he drew up a table of the tides for the use of the king, with an astronomical account of their ebbing and flowing, which Sir Jonas Moore assured him would be well received by his majesty. Sir Jonas received from Mr Flamsteed a pair of barometers, with directions how to use them, which he presented to the king and the duke of York, to whose notice he embraced every opportunity of introducing Mr Flamsteed.

Having taken the degree of master of arts at Cambridge, he formed the resolution of entering into holy orders, when Sir Jonas wrote to him to come to London, where he had an appointment for him very different from any in the church. But as Sir Jonas found that nothing could induce him to abandon the resolution he had formed, he obtained for him a situation which was perfectly consistent with the character of a clergyman. This was the new office of astronomer to the king, with a salary of L.100 per annum. In Easter 1675, he received ordination at Ely-House by Bishop Gunning; and on the 10th of August the same year was laid the foundation stone of the royal observatory at Greenwich, which received the designation of Flamsteed-House, in honour of the first astronomer-royal. Till this edifice was erected, he made his observations in the queen's house at Greenwich; and in 1681 Flamsteed's *Doctrine of the Sphere* was published by Sir Jonas Moore in his *System of the Mathematics*. But notwithstanding his extraordinary merit, he never rose higher in the church than the living of Burslow in Surrey, although he was held in deserved estimation by the greatest men in the nation. He corresponded with Sir Isaac Newton, Dr Halley, Mr Molyneux, Dr Wallis, and many others; whilst M. Cassini and he commenced their respective discoveries with the utmost confidence and cordiality. But none of his works contributed so much to establish his fame as his *Historia Cœlestis Britannica*, in three volumes folio. Mr Flamsteed was suddenly carried off by a stranguary, on the 31st of December 1719, having, notwithstanding the extreme delicacy of his constitution, and incessant labour, reached the seventy-third year of his age.

FLANDERS, a province of the Netherlands, bounded by the German Ocean and the United Provinces on the north, by the province of Brabant on the east, by Hainault and Artois on the south, and by another part of Artois and the German Sea on the west; being about sixty miles long and fifty broad. See Netherlands.

FLANEL, or Flannel, a kind of slight, loose, woollen stuff, composed of a woof and warp, and woven on a loom with two treddles, after the manner of baize.

Dr Black assigns as a reason why flannel and other substances of the same kind keep the body warm, that they compose a rare and spongy mass, the fibres of which touch each other so lightly, that the heat moves slowly through the interstices, which being filled only with air, and that too in a stagnant state, give little assistance in conducting the heat. From the experiments of Count Rumford, it appears that there is no relation between the power which the substances usually worn as clothing have of absorbing moisture, and that of keeping the body warm. Having provided a quantity of each of these substances mentioned below, he exposed them, spread out upon clean china plates, for the space of twenty-four hours, to the warm and dry air of a room which had been heated by a German stove for several months, and during the preceding six hours had raised the thermometer to 85° of Fahrenheit; after which he weighed equal quantities of the different substances with a very accurate balance. They were then spread out upon a china plate, and removed into a very large uninhabited room upon the second floor, where they were exposed forty-eight hours upon a table placed in the middle of the room, the air of which was at 45° of Fahrenheit. At the end of this time they were weighed, and then removed into a damp cellar, where they were placed on a table in the middle of the vault, the air of which was at the temperature of 45°, and, by the hygrometer, seemed to be fully saturated with moisture. In this situation they were suffered to remain three days and three nights, the vault being all the while hung round with wet linen cloths, to render the air as completely damp as possible. At the end of three days they were weighed, and the weights at the different times were found as in the following table:—

		Weight after being dried in the hot room.	Weight after coming out of the cold room.	Weight after remaining 72 hours in the vault.
Sheep's wool		Parts 1000	1084	1163
Beaver's fur			1072	1125
The fur of a Russian hare			1065	1115
Eider down			1067	1112
Silk	Raw single thread		1057	1107
	Ravellings of white taffety		1054	1103
Linen	Fine lint		1046	1102
	Ravellings of fine linen		1044	1082
Cotton wool			1043	1089
Ravellings of silver lace			1000	1000

In regard to these experiments our author observes, that though linen, from the apparent ease with which it receives dampness from the atmosphere, seems to have a much greater attraction for water than any other, yet it would appear, from what is related above, that those bodies which receive water in its unelastic form with the greatest ease, or are most easily wet, are not those which in all cases attract the humidity of the atmosphere with the greatest avidity. "Perhaps," says he, "the apparent dampness of linen to the touch arises more from the ease with which that substance parts with the water it contains, than from the quantity of water it actually holds; in the same manner as a body appears hot to the touch, in consequence of its parting freely with its heat; while another body which is really at the same temperature, but which withholds its heat with great obstinacy, affects the sense of feeling much less violently. It is well known that woollen clothes, such as flannels, &c. worn next the skin, greatly promote insensible perspiration. May not this arise principally from the strong attraction which subsists between wool and the watery vapour which is continually issuing from the human body? That it does not depend entirely on the warmth of that covering, is clear; for the same degree of warmth produced by wearing more clothing of a different kind, does not produce the same effect. The perspiration of the human body being absorbed by a covering of flannel, it is immediately distributed through the whole thickness of that substance, and by that means exposed, by a very large surface, to be carried off by the atmosphere; and the loss of this watery vapour which the flannel sustains on the one side by evaporation, being immediately restored from the other, in consequence of the strong attraction between the flannel and this vapour, the pores of the skin are disencumbered, and they are continually surrounded by a dry and salubrious atmosphere."

Our author expresses his surprise that the custom of wearing flannel next the skin should not have prevailed more universally. He is confident it would prevent a number of diseases; and he thinks there is no greater luxury than the comfortable sensation which arises from wearing it, especially after one is a little accustomed to it. "It is a mistaken notion," says he, "that it is too warm a clothing for summer. I have worn it in the hottest climates, and at all seasons of the year, and never found the least inconvenience from it. It is the warm bath of perspiration confined by a linen shirt wet with sweat, which renders the summer heats of southern climates so unsupportable; but flannel promotes perspiration, and favours its evaporation; and evaporation, as is well known, produces positive cold.

It has been observed that new flannel, after some time wearing, acquires the property of shining in the dark, but loses it on being washed. (*Philosophical Transactions*, No. 483, sect. 7.)

FLANK, or Flanc, in the manège, is applied to the sides of a horse's buttock. In a strict sense, the flanks of a horse are the extremes of the belly, where the ribs are wanting, and are immediately below the loins.

Flank, in *War*, is used by way of analogy for the side of a battalion, brigade, division, or army, in contradistinction to the *front* and *rear*.

Flank, in *Fortification*, is a line drawn from the extremity of the face towards the inside of the work. Or, flank is that part of a bastion which reaches from the curtain to the face, and defends the opposite face, the flank, and the curtain.

Fichant Flank is that whence a cannon playing fires directly on the face of the opposite bastion.

Rasant or *Razant Flank* is the point whence the line of defence begins, from the conjunction of which with the curtain the shot only rases the face of the next bastion; and this happens when the face cannot be discovered but from the flank alone.

FLANNAN Islands, a group of small islands, some six or seven in number, lying twelve miles north-west of the Isle of Skye. They are wild, rocky, and uninhabited; but from the remains of sacred edifices found upon them, they must formerly have been the residence of some Culdean or other religious order. At present they are noted for sheep pasturage.

FLATS, in *Music*. See Interval.

FLAT Island, a small island in the Eastern Seas, situated near the north coast of the island of Flores. Long. 120. 59. E. Lat. 7. 59. S. Also an island in the Mergui Archipelago, lat. 10. 27. N.; and another near the east coast of New Zealand, long. 183. 13. W. lat. 37. 40. S.

FLAVEL, John, an eminent non-conformist minister, was educated at University College, Oxford. He became minister, first of Deptford, and afterwards of Dartmouth, in Devonshire, where he resided the greater part of his life, much respected and admired for his preaching, although he was persecuted on account of his principles in 1685, when several of the aldermen of the town, attended by the rabble, carried about an effigy of him, to which were affixed the bill of exclusion and the covenant. Upon this occasion he thought it prudent to withdraw from the town, not knowing what treatment he might experience at the hands of a riotous mob, headed by magistrates who were themselves amongst the lowest of mankind. Part of his Diary, printed with his remains, will give the reader a high idea of his piety. He died in 1691, at the age of sixty-one; and after his death, his works, which consisted of many pieces of practical divinity, were printed in two volumes folio. Amongst these the most curious are his *Navigation Spiritualized, or a New Compass for Seamen*, of which there have been several editions in 8vo; and *Husbandry Spiritualized*, with occasional meditations upon beasts, birds, trees, flowers, rivers, and several other objects, of which also there have been many editions in 8vo.

FLAX. For some particulars as to the culture of flax, see the article Agriculture. What more remains to be said will be found under the connected head of Hemp.

FLAXMAN, John, an eminent English sculptor, was born at York on the 6th of July 1755. He was the second son of John Flaxman, a moulder in plaster, who, besides keeping a shop in London for the sale of his figures, sought employment in the country. He was of a weakly constitution, and slightly deformed, which prevented him from mingling with associates of his own age in the robust pastimes of youth. But he was not idle. Behind his father's counter he usually seated himself during the day, and, with drawing materials before him, busily employed himself in transferring to paper representations of the numerous figures with which he was surrounded. Indeed, almost from childhood he evinced that partiality for and love of works of art, in the creation of which he so much excelled in maturer years. But he did not confine himself to copying alone. Young as he was, he had dipped into the Iliad, and actually attempted to design historical illustrations of that immortal epic. His education seems to have devolved principally upon his parents; and as his thirst for knowledge was great, the superintendence of his studies must have been an easy task. At his books and models he laboured incessantly, and before he entered his tenth year he had made a great number of small models in plaster of Paris, wax, and clay, some of which are still preserved; and, besides being interesting as the first efforts of genius, they possess considerable merit as works of art. At ten years of age, a salutary change took place in his health. He became strong, lively, and active; and the crutches, by means of which he had hitherto walked, were thrown aside, not to be again resumed. With renovated health he came to the determination to follow sculpture as a profession. In his father's shop, where he assiduously pursued his studies, he learned form and proportion from the casts of antique statues which it contained; whilst in the woods and fields, to which he could now repair, he was supplied with new images and ideas of beauty. At the house of a Mrs Mathew, whose husband had been attracted to the youthful sculptor, Flaxman often spent his evenings hearing her read Homer and Virgil, and discourse upon sculpture and poetry; for the lady was very accomplished, and the companion of Mrs Montague, Mrs Chapone, and Mrs Barbauld. Here he was encouraged to acquire the dead languages, so necessary to one of his profession; and although he never attained to great scholarship, he, by this desultory mode of study, obtained such a knowledge of Greek as enabled him to embody the ideas of the ancient poets in a manner which no modern artist has surpassed. He embodied those passages which caught his fancy whilst he sat listening to Mrs Mathew; and the taste which he displayed in these juvenile efforts induced a gentleman to order six large drawings in chalk, the subjects being chosen from antiquity. The praise which was bestowed upon them gave new impulse to the genius of the youth, and refreshed that consciousness of superior power which he early experienced. But he never overrated himself, nor allowed his industry to relax on account of the flatteries of friends. He continued to labour assiduously in his vocation, well knowing that it was only in this manner that he could attain great eminence, and succeed in embodying those idealised conceptions of beauty which, although they scarcely admit of being defined or described, are nevertheless not less real, nor less universally acknowledged.

In his fifteenth year Flaxman became a student of the Royal Academy, and soon made himself known by assiduous and enthusiastic application. In the same year he carried off the silver medal; and in due time became a candidate for the gold one, the reward of the highest degree of merit, but proved unsuccessful. This defeat, however, only increased his assiduity. But finding himself now compelled to labour for bread, he was employed by the Wedgewoods, the enterprising potters, in making designs for adorning their wares. His sketches consisted chiefly of small groups in very low relief, the subjects being taken from ancient poetry and history. Previously to this period the porcelain of England had little external beauty to recommend it; and the genius of Flaxman may be said to have created this branch of art in his native country. The rude and unseemly shapes which formerly prevailed were no longer tolerated, and figures of classic elegance and beauty were invented to supply their place. In 1782, Flaxman having quitted his paternal roof, took a small house, and entered into a matrimonial alliance with a person of considerable accomplishments, in whose society he enjoyed much domestic happiness. During the ten years which preceded this event, he had exhibited some thirteen works at the Royal Academy, but, from the pecuniary difficulties under which he laboured, none of these were executed in marble. Shortly after his marriage, he formed the resolution of studying at Rome, and at the end of five years of incessant labour, during which he executed several monuments and other works of considerable merit, he was enabled to carry his design into execution. It is unnecessary to observe, that Flaxman, like every other artist, was struck with the noble specimens of art which Italy possesses, and that by a close study of these he greatly improved himself. But he was no servile imitator, for he was as capable of creating as of copying. In Rome Flaxman executed a number of works. For three individuals of his own country he illustrated Homer, Æschylus, and Dante. These designs are splendid, being varied with great skill, and drawn with a fine sense of the beautiful and harmonious in composition. Of works in marble he executed a small size group of Cephalus and Aurora; a statue of Lord Mansfield; a group representing the fury of Athamas, from Ovid's *Metamorphoses*, consisting of four figures of the heroic size; and the restoration of that splendid torso which is generally believed to be a fragment of a Hercules. This last undertaking was as difficult as it turned out to be thankless. He not only completed the figure of Hercules, but added another of Omphale. But this statue did not give satisfaction to the connoisseurs of Italy, and Flaxman caused it to be destroyed some time previously to his death, without any injury to his fame. The remains of ancient sculpture in Rome, and in other cities of Italy, engaged not a little of his attention. He executed numerous drawings, and made a great many memoranda, the most valuable of which were subsequently embodied in his lectures on sculpture. He had been elected a member of the academies of Florence and Carrara; and after seven years' residence in a foreign country, he at length returned to his own.

Flaxman's statue of Lord Mansfield had raised the expectations of his countrymen to a high pitch. In 1797 he was elected associate of the Royal Academy, during which year he sent to the exhibition three sketches in bas-relief from the New Testament, and a monument to Sir William Jones. The sketches are distinguished for their elegance of grouping. The monument is a bas-relief, but not one of the artist's most fortunate efforts in that line. In the forty-fifth year of his age Flaxman was elected a member of the Royal Academy, and, as is usual on such occasions, presented to the institution a work of art. His offering on this occasion was a marble group of Apollo and Marpessa; the conception of which is fine, though the workmanship is not so good. In the mechanical use of the chisel he never excelled. It was now his ambition to be employed upon some great national work, and he proposed to make a statue of Britannia two hundred feet in height, but the project was not carried into execution. His fame, however, was now firmly established, and employment flowed rapidly in. A quick succession of noble works followed from his hand, one of which, a monument in memory of the family of Sir Francis Baring, is considered among the greatest efforts of the national genius of England. One of his biographers remarks with respect to it, "This is one of the finest pieces of motionless poetry in the land." Of historical monuments Flaxman executed several, but they are not equal to his other works. They have been admired for the fine sentiment which pervades them, but their execution is considered by many as too coarse and heavy. The statue of Sir Joshua Reynolds is one of his best productions. But the works he loved most were those which embodied poetical passages in the Bible, and of these he executed a great number. In 1810 the Royal Academy created a professorship of sculpture, and bestowed it upon Flaxman. His lectures are ten in number. The style is rather heavy; yet although his compositions are destitute of those flashes of poetry which irradiate the pages of Fuseli, they display a very comprehensive knowledge of the subject, much sound sense, and are more calculated to convey definite information to the student than those of the other artist above named. But if the offspring of his pen was cold and uninformed with ideal beauty, the productions of his pencil and chisel display an exuberance of imagination. His sketches and drawings are very numerous. Amongst the works which he illustrated were the Pilgrim's Progress, Sotheby's translation of Oberon, and Hesiod. These designs are in all respects fully equal to his other works, and unsurpassed by any thing which ever was executed in that line. During the last ten years of his life Flaxman produced some of his noblest works. Amongst these were the group of the Archangel Michael vanquishing Satan, the Shield of Achilles, Psyche, the Pastoral Apollo, and the statues of Michel Angelo and Raffaelle. The first is a work of the highest merit, and worthy of the great poem which it illustrates. "In the Psyche and the Pastoral Apollo," says Mr Allan Cunningham, "the genius of him who illustrated Homer is sufficiently apparent; a certain austere composure is breathed over them. The Michael Angelo and the Raphael are poetic, yet real; heroic, yet familiar; and their costume, though not antique, is at once historic and picturesque." Flaxman's statues of Burns and Kemble, executed about the same time, are scarcely so happy. Amongst his other works were monuments to Collins at Chichester, and to Earl Howe in St Paul's; and statues of Washington, Nelson, Pitt, and Sir John Moore. They are of various excellence, yet all more or less bear the impress of genius and taste. But the career of this great sculptor was drawing to a close. In the beginning of December 1826 he was seized with an inflammation of the lungs, which terminated fatally on the 7th of the same month.

In stature Flaxman was small, and his figure was slim. In manners he was mild, gentle, and placable; and his mind, whilst it was rich in the gifts of genius, was embued with unaffected piety. Of his works there are four kinds; the religious, the poetic, the classic, and the historical. In each of these he has left specimens which entitle him to rank very high as an artist, but in all he has not attained the same degree of excellence. In the historical and the classic he was less successful; but in the religious and poetic he has been surpassed in purity, simplicity, and taste, by no modern sculptor. His religious compositions consist of groups and figures embodying moral and spiritual passages from Scripture. They are generally of small dimensions, but very numerous. His mind was essentially poetical; and his productions are embued with the finest inspiration. It was probably of some of these works that Sir Thomas Lawrence spoke when he said of Flaxman, "His solitude was made enjoyment to him by a fancy teeming with images of tenderness, purity, or grandeur. His genius, in the strictest sense of the words, was original and inventive." His lectures were published in 1829, in one vol. 8vo, illustrated with fifty-two plates.

FLEAM, in *Surgery* and *Farriery*, an instrument for letting blood of a man or horse. A case of fleams, as it is called by farriers, comprehends six sorts of instruments; two hooked ones, called *drawers*, which are used for cleansing wounds; a pen-knife; a sharp-pointed lancet for making incisions; and two fleams, one sharp and the other broad pointed. These last are somewhat like the point of a lancet, fixed in a flat handle, and no longer than is just necessary to open the vein.

FLECHE, LA, an arrondissement in the department of the Sarthe, in France. It extends over 722 square miles, is divided into seven cantons, and these into eighty communes, containing 84,995 inhabitants. The capital, a city of the same name, is a well-built place, situated on the river Loir, in a valley surrounded with vineyards. It contains 843 houses, and 5099 inhabitants. There is a public school for military instruction, with a good library. Long. 0. 13. W. Lat. 47. 22. N.

FLECHIER, ESPRIT, bishop of Nismes, one of the most celebrated preachers of his age, and author of a number of works, was born at Pernes, a small town in the diocese of Carpentras, on the 10th of June 1632, and educated under the eye of his uncle, Father Audifret, general of the congregation of Christian doctrine, a learned and estimable man. According to the constitution of the congregation, Fléchier, having completed his own education, was immediately employed in teaching. In 1659, when only twenty-seven, he professed rhetoric at Narbonne, and there pronounced the funeral oration of M. de Rebé, archbishop of that city, which, however, is not to be found in his collected works, probably because it was deemed unworthy of the reputation which he subsequently acquired. A few months afterwards, on the death of Audifret, followed as it was by some changes in the government of the congregation, which he did not relish, Fléchier laid aside the habit of the *doctrinaires*, and proceeded to Paris, where he was at first employed in the humble occupation of a parochial catechist; but he soon made himself known by his Latin and French poetry, and particularly by a description in Latin verse of the brilliant carousal, *Circus Regius*, given by Louis XIV. in 1602. This was the commencement of Fléchier's reputation. He was now entrusted with the education of Louis Urbain Lefèvre de Caumartin, afterwards intendant of finances and counsellor of state; and as the house of Louis de Caumartin, the father of his pupil, was then frequented by the most considerable personages both of the court and the city, Fléchier was thus introduced into the first society, amongst which his talents, amiability, gentleness of demeanour, and regularity of manners, soon procured him many friends. The Duke of Montausier, who was not prodigal of his notice, conceived a great regard for Fléchier, declared himself his patron, and having presented him to the dauphin, procured him the place of reader to that young prince. The sermons of Fléchier increased his reputation, which was afterwards raised to the highest pitch by his funeral orations. Having been chosen to pronounce that of Madame de Montausier, he displayed so great talent on the occasion that his discourse opened to him the doors of the French Academy, into which he was received in 1673, in the room of M. Godeau, bishop of Venice. He was admitted the same day with Racine, and having precedence in addressing the Academy, his discourse was warmly applauded; the great poet however was less fortunate than the orator, for his address being scarcely audible, was coldly received and unfavourably judged of; so much is chance concerned even in the success of eminent merit. The favours of the court now flowed upon Fléchier. The king gave him successively the abbey of St Leverin, in the diocese of Poitiers, the office of almoner to the dauphiness, and, in 1685, the bishopric of Lavaur, accompanying his kindness with the most flattering expressions of favour and regard. "I have made you wait a little for a place which you have long merited," said the monarch; "but I did not wish to deprive myself sooner of the pleasure of hearing you." From the see of Lavaur Fléchier was, in 1687, translated to that of Nismes, which was more valuable, and also accounted more honourable. His own wish was to remain at Lavaur; but the king overcame his repugnance to the proposed translation by making him sensible that he would be more useful to the church at Nismes than at Lavaur, and that in the former place there was more labour to be performed and more good to be done. In fact the Calvinists were very numerous at Nismes; and although several had made abjuration, their conversion was at best but equivocal. But Fléchier, by his prudent conduct, in which zeal was tempered by charity, brought back the greater number of these sectaries to the bosom of the church, and made himself esteemed and beloved even by those who declined to abjure their faith. During the troubles in the Cevennes he softened, as much as in him lay, the rigour of the edicts, and showed himself so sensible of the evils of persecution, and so indulgent even to what he regarded as error, that his memory is, even at this day, held in veneration amongst the Protestants of that district. In the famine which succeeded the winter of 1709, he distributed immense sums, making no distinction between Catholics and Protestants; all were his children, and all shared his beneficence in proportion to their respective wants. He also published an eloquent pastoral letter on the subject of a cross of St Gervais, which, it was pretended, worked miracles, and warned his flock against those lying wonders, by which the credulity of the people has frequently been abused. This appears to have been amongst his last efforts in the cause of truth and religion. The good bishop, indeed, foresaw that his end was now approaching; and, having prepared for himself a humble tomb, he died at

Montpellier on the 16th February 1710, at the advanced age of seventy-eight. "He died," says D'Alembert, "lamented by the Catholics, regretted by the Protestants, and having always exhibited to his brethren an admirable model of zeal and charity, simplicity and eloquence." Fléchier's works are, 1. *Antonii Mariæ Gratiani de Vita Joannis Francisci Commendoni Cardinalis* libri iv. Paris, 1669, in 12mo; 2. *La Vie du Cardinal Commendon*, Paris, 1671, in 4to; 3. *De Casibus Virorum Illustrium autore Antonio Maria Gratiano, opera et studio Sp. Flecherii*, Paris, 1680, in 4to; 4. *Histoire de Théodose-le-Grand*, Paris, 1679, in 4to, composed for the education of the dauphin; 5. *Histoire du Cardinal Ximenes*, Paris, 1693, in 4to; 6. *Oraisons Funèbres*, 1681, in 4to and in 12mo; 7. *Panégyriques des Saints*, Paris, 1690, in 4to; 8. *Sermons de Morale prêchés devant le Roi, avec des Discours synodaux et les Sermons prêchés par Fléchier aux Etats de Languedoc et dans sa Cathédrale*, in 3 vols. 12mo; 9. *Œuvres Posthumes, contenant ses Harangues, Compliments, Discours, Poésies Latines, Poésies Françaises*, Paris, 1712, in 12mo; 10. *Mandements et Lettres pastorales, avec son Oraison funèbre par l'Abbe du Jarry*, Paris, 1712, in 12mo; 11. *Lettres Choisies sur divers sujets*, Paris, 1715, in 2 vols. 12mo; 12. *Relation d'un Voyage en Auvergne.* The only collection yet published of the works of Fléchier is that of the Abbé Ducreux, canon of Auxerre, which appeared under the title of *Œuvres Complètes de Messire Esprit Fléchier*, Nismes, 1782, in 10 vols. 8vo. If we except the History of Theodosius, pulpit eloquence is the only branch of the belles-lettres cultivated by Fléchier in which he excelled. His Funeral Orations have been compared with those of Bossuet, without attending to this distinction, that comparisons become useless between two kinds of genius which are totally different. That of Bossuet was sublime throughout. Fléchier, on the other hand, was only remarkable for the nobleness of his thoughts and the harmony of his diction. It is true that he possessed in an eminent degree these two qualities of an orator, and that nobody has carried the latter further than he; but even in that department where he has been most successful, Fléchier is not without faults, and may be reproached with an ambition of giving point to his thoughts, an affectation of symmetry in the style, and a love of antitheses, all at variance with the principles of good taste. But if his funeral orations and sermons lose much of their merit by a too measured elegance, his pastoral instructions and synodal discourses are wholly free from such affectation, indeed as remarkable for simplicity of style as for generosity of sentiment, and that indulgent spirit which laments whilst it combats error, and which, repudiating all attempts at persecution, seeks to win men over to the right way, not by the instrumentality of fear, but through the medium of their understanding and affections. "C'est dans ces ouvrages," says a distinguished French critic, "que la philosophie elle-même apprendra l'usage qu'on doit faire des lumières et du sentiment, et se convaincra que l'humanité n'a pas de consolation plus solide que la religion, comme la politique n'a pas de meilleur appui." (A.)

FLECKNOE, Richard, an English poet and dramatic writer in the reign of Charles II. who has been more indebted for the preservation of his name to Dryden's satire of *Mac-Flecknoe*, than to the merit of his own productions, is said to have been originally a Jesuit, and connected with some persons of distinction belonging to the Roman Catholic persuasion. The origin of Dryden's antipathy to this man has not been ascertained. It was confirmed, however, when the office of poet-laureat, of which Dryden had been deprived on account of his religion, was conferred upon Flecknoe; and resentment of this wrong appears to have produced the celebrated satire above mentioned, which, besides being equally spirited and amusing in itself, served in some degree as the model of the Dunciad. Flecknoe wrote some plays, but not more than one of them was ever acted. His comedy called *Damoiselles à la Mode* was printed in 1667, and addressed to the Duke and Duchess of Newcastle; but the players refused to perform it. His other dramatic pieces were *Ermina, or the Chaste Lady; Love's Dominion*, printed in 1654; and *The Marriage of Oceanus and Britannia.* His other works consist of, 1. *Epigrams and Enigmatical Characters*, 1670, in 8vo; 2. *Miscellanea*, or Poems of *all* sorts, with divers *other* pieces, 1653, in 12mo; 3. *Diarium*, or the Journal, divided into twelve Jornadas, in burlesque verse, London, 1656, in 12mo. Flecknoe died in 1678. Mr Southey, in his *Omniana*, has generally endeavoured to vindicate him from some of the ridicule thrown upon him as a writer, and from certain grave reproaches made against his character as a man. (A.)

FLEECE, the covering of wool shorn off the bodies of sheep. See the article Wool.

FLEET commonly implies a company of ships of war belonging to any prince or state; but sometimes it denotes any number of trading ships employed in a particular branch of commerce.

Fleet is also a noted prison in London, where persons are committed for contempt of the king and his laws, particularly of his courts of justice; or for debt, where any person will not or cannot pay his creditors. See London.

FLEETWOOD, William, a learned English bishop, descended of an ancient family in Lancashire, was born in the Tower of London, where his father resided, on the 21st of January 1656. He received his education at Eton, and at King's College, Cambridge. About the time of the Revolution he entered into holy orders, and having soon become a distinguished preacher, was appointed chaplain to King William and Queen Mary. By the interest of Dr Godolphin, vice-provost of Eton, and residentiary of St Paul's, he was appointed rector of St Austin's, London, which is in the gift of the dean and chapter of St Paul's; and soon afterwards he also obtained the lectureship of St Dunstan's in the West. In 1691 he published his *Inscriptionum Antiquarum Sylloge*, in two parts; one containing remarkable Pagan inscriptions, and the other ancient Christian monuments. In 1692 he published a translation of Jurieu's *Plain Method of Christian Devotion*, the twenty-seventh edition of which was printed in 1750. In 1701 appeared his Essay on Miracles, which called forth the animadversions of several writers, particularly Hoadly. In 1704 he published anonymously, The Reasonable Communicant; and in 1705, Sixteen Practical Discourses on the relative duties of parents and children, husbands and wives, masters and servants, with three sermons on the case of self-murder. Having a natural inclination for the study of British history and antiquities, he gave a specimen of his skill in these pursuits by publishing, in 1707, his *Chronicon Preciosum*, containing an account of the English money, the price of corn and other commodities, for the preceding six hundred years. In the previous year he had, without any solicitation on his part, been nominated to the see of St Asaph, upon the death of Beveridge; but he was not consecrated until June 1708. His conduct as a bishop was highly exemplary, and such as became the episcopal character. In 1710 he published a vindication of the thirteenth chapter to the Romans, upon the authority of which the regal dignity had been so magnified by some as to make tyranny seem an ordinance of God, and to represent the most abject slavery as founded upon the principles of religion. This degrading doctrine was highly offensive to Bishop Fleetwood, who, in this tract, contends that, in the chapter referred to, St Paul requires of no people any more submission to the higher powers than that which is enjoined by the laws of their several countries.

In 1712 he published Four Sermons, one on the death of Queen Mary in 1694, another on that of the Duke of Gloucester in 1700, a third on that of King William in 1701, and a fourth on the accession of Queen Anne; and also, the same year, an anonymous tract on Lay Baptism, according to the Church of England, a subject which then engaged a good deal of attention. The Life and Miracles of St Wenefrede, together with her Litanies, appeared in 1713, likewise without his name; the object of which was to expose the absurd superstitions by which weak minds are apt to be influenced, and, in particular, to show the delusions which had been practised under the names of pretended saints. In 1714 he was translated from the see of St Asaph to that of Ely, vacant by the death of Dr Moore, and continued there till his death, which took place at Tottenham, Middlesex, on the 4th of August 1723. The remaining works of Bishop Fleetwood are these: 1. The Chancellor's Plea in the Divorce of Sir G. Downing, 1715; 2. Papists not excluded from the Throne on account of Religion, 1717; 3. A Letter from Mr T. Burdett, executed at Tyburn for the murder of Captain Falkner, to some attorneys' clerks of his acquaintance, 1717; 4. A Letter to an Inhabitant of the Parish of St Andrews, Holborn, about New Ceremonies in the Church, 1717; and, 5. A Defence of Praying before Sermon, as directed by the fifty-fifth canon. All these tracts, however, were published without the author's name. Bishop Fleetwood's character stood deservedly high in general estimation. His virtue was without any alloy of fanaticism, and his piety wholly untinctured with superstition. He was the friend of liberty and learning, equally zealous in defending the one and in encouraging the other. He assisted Dr Hickes in his great work, *Linguarum veterum Septentrionalium Thesaurus;* and Hearne confesses himself to have been under many obligations to the same excellent person. In a professional point of view he was unquestionably the best preacher of his time; and his occasional sermons exhibit a felicity of adaptation to the circumstances that had called them forth, which we should perhaps seek for in vain in any other compositions of the kind. In a word, Dr Fleetwood was an honour to the church, of which he was a distinguished member, and an ornament to a hierarchy which has been illustrated by some of the greatest names to be found in the history of English literature. (A.)

FLEMINGIANS, or FLANDRIANS, in *Ecclesiastical History*, a sect of rigid Anabaptists, who acquired this name in the sixteenth century, by way of distinction from the *Waterlandians*. In consequence of some dissensions among the Flemingians relative to the treatment of excommunicated persons, they were divided into two sects, distinguished by the appellations of *Flandrians* and *Frieslanders*, who differed from each other in their manners and discipline. But in process of time many of these came over to the moderate community of the Waterlandians, whilst those who continued separate still retained the name of the old Flemingians or Flandrians. They maintained the opinion of Menno with respect to the incarnation of Christ; alleging that his body was produced by the creative power of the Holy Ghost, and not derived from his mother Mary.

FLEMISH, or the FLEMISH TONGUE, that which is otherwise called *Low Dutch*, to distinguish it from the *German*, of which it is a corruption and a kind of dialect. It differs from the *Walloon*, which is a corruption of the French language. The Flemish is used throughout all the provinces of the Netherlands.

FLENSBURG, a city of the duchy of Sleswick, in Denmark. It is finely situated on a fiorde or arm of the sea, from which rises hills on three sides, on which the city is built, and from the sea resembles an amphitheatre. It contains 1208 houses and 13,109 inhabitants. It is a place of great trade and manufactures, the chief port to which ships from the West Indies repair. The manufactures are numerous, being assisted by good water power. There are several institutions for education and for charitable purposes, and some delightful promenades and prospects. Long. 9. 21. E. Lat. 51. 17. N.

FLESH, in *Anatomy*, a compound substance, consisting of the various softer solids of the animal body, and so denominated in contradistinction to bones. See ANATOMY, *passim*.

FLETA, the name given to an unknown writer who lived about the end of the reign of Edward II. and beginning of Edward III. and who, whilst a prisoner in the Fleet, wrote an excellent treatise on the common law of England.

FLETCHER. See BEAUMONT AND FLETCHER.

FLETCHER, *Andrew*, of Saltoun, a celebrated Scottish patriot and political writer, was descended from an ancient family, who traced their origin to some one of the followers of William the Conqueror. He was the son of Sir Robert Fletcher of Saltoun and Innerpeffer, and was born in the year 1650. The tuition of young Fletcher was committed by his father, on his deathbed, to Mr, afterwards Bishop, Burnet, then his parish minister, to whose care and attention he was indebted for a pious, learned, and polite education. Being endowed with uncommon genius, and possessed of virtues and abilities peculiarly suited to the times in which he lived, Mr Fletcher quickly shone forth the ornament of his country and the champion of its freedom. Having in the course of his classical studies and historical reading been impressed with an enthusiastic admiration both of ancient and modern republics, he had early contracted an ardent love of liberty, and an aversion to arbitrary rule. Hence his spirit the more readily took alarm at certain measures in the reign of Charles II. Being knight of the shire for Lothian to the parliament where the Duke of York appeared as commissioner, he openly opposed the designs of that prince and the bill of accession; and he had a share with Lord Viscount Stair in framing the test act, by which the Duke of York complained that he had lost Scotland. On these accounts he became peculiarly obnoxious to his royal highness, and was at last obliged to fly to Holland, to avoid the fatal consequences of prosecutions which on various pretences were commenced against him. Being cited before the privy council and justiciary courts, and not appearing, he was declared a traitor, and his estate confiscated.

In Holland, Fletcher and Baillie of Jerviswood were the only persons whom the Earl of Argyll consulted concerning the designs which were then in agitation. In 1681 they came over to England in order to concert matters with their party in that country; and they were the only persons who were entrusted so far as to be admitted to the secrets of Lord Russell's council of six. Mr Fletcher managed his part of the negotiation with so much address, that the administration could find no pretext for seizing him; nor could they fix upon him those articles on account of which Baillie was condemned; and to the honour of the latter be it remembered, that although offered a pardon on condition of accusing his friend, he persisted in rejecting the proposal with indignation.

Mr Fletcher having joined the Duke of Monmouth upon his landing, received a principal command under him; but the duke was deprived of his services owing to a circumstance which is related by Sir John Dalrymple. Being sent upon an expedition, and not esteeming "times of danger to be times of ceremony, he had seized for his own riding the horse of a country gentleman (the mayor of Lynne), which stood ready equipped for its master. The master, hearing this, ran in a passion to Fletcher, gave him opprobrious language, shook his cane, and attempted to strike. Fletcher, though rigid in the duties of morality, having been accustomed to foreign service both by sea and land, in which he had acquired high ideas of the honour of a soldier and a gentleman, and of the affront of a cane, pulled out his pistol and shot him dead on the spot. The action was unpopular in countries where such refinements were not understood. A clamour was raised against it among the people of the country; in a body they waited upon the duke with their complaints; and he was forced to desire the only soldier, and almost the only man of parts, in his army, to abandon him. With Fletcher all Monmouth's chance of success in war left him." In a manuscript memoir belonging to the family there is the following notice concerning Mr Fletcher's connection with Monmouth, in which his separation from that prince is very differently accounted for: "To Lord Marischal Mr Fletcher explained the motives which first induced him to join, and afterwards abandon, the Duke of Monmouth. The former he ascribed to the duke's manifesto in Scotland relating to religion, and in England to liberty. For the latter he accounted by the disgust produced in his own mind, and that of his associates, when the duke declared himself king, and broke faith with all who had embarked with him on his principles. He complained heavily of the account commonly given of the death of the mayor of Lynne; and mentioned to Lord Marischal, in proof of the contrary, that he did not leave the duke till he came to Taunton, where he was proclaimed king, several weeks after the death of the mayor of Lynne."

Seeing all the efforts of his friends and of himself in favour of liberty frustrated at Taunton, he endeavoured to secure his own personal freedom by taking his passage in the first ship bound to a foreign country. It was his misfortune, however, to land in Spain, where he was immediately arrested, cast into prison, and guarded by three different bands of soldiers, till a vessel could be prepared to carry him a victim in chains to the court of London. But on the morning upon which the ship was to sail, whilst he looked pensively through the bars of his window, he was hailed by a venerable personage, who made signs to speak with him. The prison doors he found open; and whilst his friendly conductor motioned to him to follow, he passed through three different guards of soldiers all fast asleep. Without being permitted to offer his thanks to his deliverer, he found himself obliged to prosecute with all speed his journey, in which he was directed by a person concerning whom he could never collect any information, and thus he proceeded in safety through Spain.

During his exile he maintained a frequent and extensive correspondence with the friends of liberty at home, and he partly employed himself in making a curious collection of books. But his genius also prompted him to engage in more active employments. He repaired to Hungary, and served several campaigns with much reputation as a volunteer under the Duke of Lorrain. At length, understanding that the great design then projected in Holland, and upon the issue of which he considered the liberties of Britain to depend, had obtained a considerable degree of maturity, he hastened thither, and his counsels and address were of eminent service to the cause. He came over with King William; and in zeal, activity, penetration, and political skill, proved inferior to none of the leaders in the Revolution.

Such, however, was his magnanimity, that whilst others laboured to render this grand event a source of emolument to themselves and aggrandisement to their families, Mr Fletcher asked for nothing. His estate had been forfeited, and his house abandoned to military execution; his fortune was greatly shattered, and his family reduced to circumstances of distress; yet nothing was given him in recompense of all his sufferings. On the contrary, he had the honour, along with the Duke of Hamilton, to be distinguished by marks of both royal and ministerial dislike. Still, whatever private resentment he might entertain, his ruling principle was the good of his country, and to this grand object of his heart he was willing to sacrifice all personal considerations. Accordingly, in 1692, when the abdicated king meditated an invasion, Mr Fletcher addressed a letter, preserved in Sir John Dalrymple's collection, to the Duke of Hamilton, in which every argument is employed with skill and energy to engage his grace to forget his injuries, and in the actual crisis to employ the extensive influence which he then possessed in the cause of freedom and of his country. This letter produced its full effect, and the duke returned to his duty, from which he had in some degree begun to estrange himself.

To follow our author throughout all the mazes of his political life subsequently to the Revolution, is beyond our purpose, and would exceed our limits. It will be sufficient to mention one or two additional circumstances illustrative of his character. Being elected a member for the parliament 1693, he showed an uniform zeal for the interest of his country. The thought of England domineering over Scotland was what his generous soul could not endure. The indignities and oppression which Scotland lay under galled him to the heart; and in his learned and elaborate discourses he exposed them with undaunted courage and affecting eloquence. In that great event, the Union, he performed essential service. He got the act of security passed, which declared that the two crowns should not be placed on the same head until Scotland had been secured in her civil and religious liberties. After the queen's demise, therefore, Lord Godolphin was forced into the Union, in order to avoid a civil war. Although Mr Fletcher disapproved of some of the articles, and indeed of the whole frame of the Union; yet, as the act of security was his own work, he had all the merit of that important transaction.

We must not omit mentioning, that in the ardour of his political career Mr Fletcher forgot not the interests of the place which gave him birth. He esteemed the education of youth as one of the noblest objects of government. On this subject he wrote a treatise, still extant, which is most characteristic of himself; and he established at Saltoun a foundation for the same purpose, of great utility while it lasted. This remarkable person died at London in 1716, at the age of sixty-six, and his remains were conveyed to Scotland, where they were deposited in the family vault at Saltoun.

Mr Fletcher was master of the English, Latin, Greek, French, and Italian languages, and well versed in history, the civil law, and other kinds of learning. In his travels he had not only acquired considerable knowledge in the art of war, but had also become conversant with the respective interests of the several princes and states of Europe. In private life he was affable to his friends, and free from all manner of vice. He had a penetrating, clear, and lively apprehension; but is said to have been too much wedded to opinions, and impatient of contradiction. He was by far the finest speaker in the parliament of Scotland, and the Earl of Stair alone rivalled him. The latter was famed for a splendid, the former for a close and nervous eloquence.

In 1698 he published a *Discourse on Government with Relation to Militias*, and two *Discourses concerning the Affairs of Scotland*. These and some other pieces, together with a few of his speeches, were after his death collected and published in an octavo volume, entitled *Political Works of Andrew Fletcher, Esq.*

FLETCHER, *Phineas*, an English poet who enjoyed considerable popularity in his own day, but regarding whom few particulars have descended to posterity. He was the son of Dr Giles Fletcher, who, on account of his abilities, was entrusted by Queen Elizabeth with several important missions, especially one to Russia, in which he negotiated a treaty highly advantageous to England. He published an account of *The Russe Commonwealth*, which was at first suppressed, but afterwards reprinted in 1643. Phineas, his eldest son, was educated at Eton, and in 1600 was elected to King's College, Cambridge, where he took the degrees of bachelor and master of arts. Having entered into holy orders, he received the living of Hilgay in Norfolk in thé year 1621. It appears from Blomefield's *Norfolk*, that he continued to officiate in his clerical capacity for twenty-nine years, and it is probable that he died here. These are all the facts known regarding Phineas Fletcher, a poet who was styled "the Spenser of his age," but whose fame is scarcely equal to his merit. He wrote *Sicelides*, a piscatory drama, which was printed anonymously in 1631. In the year following he printed at Cambridge a work entitled *De literatis antiquæ Britanniæ, præsertim qui doctrina claruerunt, quique collegia Cantabrigiæ fundarunt*, 12mo. In the year following he printed, in one vol. 4to, his *Purple Island*, *Piscatory Eclogues*, and *Miscellanies.* These poems have all been reprinted, but not frequently. They are, however, to be found in Anderson's *British Poets*.

The character of Phineas Fletcher appears to have been mild and amiable, and his contemporaries passed liberal encomiums upon him for his learning and piety. As a poet he possesses more merit than posterity seems disposed to attribute to him. The *Purple Island* is his longest and his best production. It is an allegorical poem, of which man is the subject. The first five cantos may be entitled the anatomy of the human body in rhyme. In the remainder of the poem the poet quits the dissecting-room for the academic grove of intellectual philosophy, and the learning of the schools. Although the design is bad, and the reader sickens over anatomical details and abstract subtilties, it is impossible not to admire the ingenuity with which the writer has invested them with the flowers of fancy and of poetry. There is a profusion of images; and although, as might have been expected, many of his allegorical personations are too elaborately drawn and too highly coloured, some of them are distinguished by a boldness of outline, a majesty of manner, a brilliancy of tint, a propriety of attribute, and an air of life, which are rarely met with in modern productions, and rival the best things of the kind even in Spencer, the author from whom he caught his inspiration. Too often, indeed, his conceptions are incongruous, and his conceits fantastical; but many beautiful thoughts are interspersed throughout, and the whole is enriched with a vein of genuine poetry.

FLETCHER, *Giles*, brother of the preceding, and of whom also few memorials remain, was born in the year 1558. He was bred at Cambridge, and died at his living at Aldenston in Suffolk, in the year 1623. He is principally known as the author of *Christ's Victory and Triumph over and after Death*, a poem characterized by a tone of enthusiasm peculiarly solemn. Like his brother, he was an imitator of Spencer, and, with the diction of the latter slightly modernized, he retains much of his melody and luxuriant expression. Giles Fletcher, there can be no doubt, is inferior both to Spencer and Milton, but he frequently reminds us of both; and it seems evident that the latter was indebted to him for hints, particularly with reference to *Paradise Regained;* and some of the finest parts of *Paradise Lost* appear likewise to have been suggested by passages in *Christ's Victory and Triumph*. Although in several parts rather fantastical and quaint, that poem is a fine effusion of genius, and one of the best productions of the kind in the language.

FLETEWOOD, WILLIAM, an eminent English lawyer and recorder of London in the reign of Queen Elizabeth. He was very zealous in suppressing mass-houses, and in imprisoning Roman Catholic priests; but having once rushed in upon mass at the Portuguese ambassador's house, he was committed to the Fleet for breach of privilege. Mr Wood says he was a learned man and a good antiquary, but of a marvellous merry and pleasant conceit. He was a good popular speaker, and wrote well upon subjects of government. His principal works are, 1. *Annalium tam regum Edwardi V. Richardi III. et Henrici VII. quam Henrici VIII.;* 2. *A Table of the Reports of Edmund Plowden;* 3. *The Office of a Justice of Peace.* He died about the year 1593.

FLEURY, CLAUDE, sub-preceptor of the young princes of France, was the son of an advocate before the council, originally from Rouen, and born at Paris on the 6th of December 1640. He studied under the Jesuits, in the College of Clermont, where he passed six years; and he ever afterwards cherished sentiments of the liveliest gratitude towards his kind and able masters. Being intended by his father for the bar, he now applied himself to the study of the civil law and of history, to which he added the belles-lettres, for which he had a strong predilection, and he was admitted as an advocate before the parliament of Paris in 1658. He remained at the bar nine years, during which time the peaceable life he led, a natural taste for solitude, and religious sentiments, the fruits of his early education, insensibly produced in his mind an inclination for the church. As soon as his resolution was fixed, he made a corresponding change in his pursuits, and the works which had hitherto been the objects of his study were replaced by theology, the fathers, ecclesiastical history, and the canon law, in all which he became very learned. He had already been some time in priest's orders, when, in 1672, he was chosen, on account of his merit, as preceptor to the sons of the Prince of Conti, who were educated along with the dauphin. At the expiration of this engagement, the king, who had occasion to observe and appreciate his merit, entrusted him with the education of the Count of Vermandois, which, however, he did not complete, as this young prince died in 1683. In 1684, the king conferred on him the abbey of Loc-Dieu, belonging to the order of Citeaux; and in 1689, appointed him sub-preceptor to the Dukes of Burgundy, Anjou, and Berry. The Abbé Fleury having thus found himself associated with Fénélon, shared the labour which that illustrious prelate bestowed on the education of his august pupils, and contributed essentially to its success. It was in 1696, whilst he was still occupied with the instruction of the princes, that he was named one of the forty of the French Academy to fill the place of La Bruyère. In other respects he led as retired a life at court as he could have done in the most profound solitude. Entirely occupied with the duties of his office, to which he devoted himself without reserve, he had but few moments of leisure; but these, when he could command them, were given to useful pursuits. When the education of the princes was completed, Louis, who not only knew how to distinguish talents, but also how to reward them, conferred on Fleury the rich priory of Argenteuil; upon which the abbé, faithful to the discipline established by the canons, resigned his abbey into the hands of the king. It was then that, free from all care, he devoted himself entirely to pursuits worthy a man of his station; but Louis XIV. having died, in 1716, he was recalled to the court by the regent, to become confessor to the young king. In appointing him to this office the regent is reported to have said, "I have chosen you because you are neither Jansenist, nor Molinist, nor Ultramontanist." Fleury discharged with zeal and sagacity the delicate functions of his new situation, which, however, he resigned in 1722, by reason of his great age. He died on the 14th of July 1723, in his eighty-third year. Fleury was alike remarkable for his great learning and extreme simplicity of manners; in him Christian humility was blended with true dignity, and the gentlest disposition with the loftiest spirit. He was mild, affable, benign, charitable; an ardent lover of truth, and a bright pattern of those virtues which he inculcated on others. His understanding, naturally excellent, was cultivated with infinite labour; and his heart was as carefully disciplined as his understanding. Profound knowledge, sterling rectitude of principle, innocent manners, a simple, laborious, and edifying life, sincere modesty, admirable disinterestedness, unfailing regularity, and the utmost fidelity in the discharge of all his duties; such are the traits of the character of Fleury as delineated by his contemporaries; a character which, in their judgment, exhibited an assemblage of all the talents and virtues which form the profound scholar, the honest man, and the devout Christian. The following is a list of the numerous works which he left behind him, part of which were composed during brief snatches of leisure, whilst occupied with the education of his different royal and noble pupils: 1. *Histoire du Droit Français*, 1674, in 12mo; 2. *Catéchisme Historique*, Paris, 1679, in 12mo; 3. *Les Mœurs des Israélites*, Paris, 1681, in 12mo; 4. *Les Mœurs des Chrétiens*, 1682, in 12mo; 5. *La Vie de la vénérable mère Marguérite d'Arbouze, abbesse et reformatrice du Val-de-Grâce*, Paris, 1684, in 8vo; 6. *Traité du choix et de la méthode des Etudes*, Paris, 1686, in 12mo; 7. *Institution au Droit Ecclésiastique*, Paris, 1687, in 2 vols. 12mo; 8. *Les Devoirs des Maîtres et des Domestiques*, Paris, 1688, in 12mo; 9. *La Traduction Latine de l'Exposition de la Doctrine de l'Eglise Catholique par Bossuet*, Antwerp, 1678, in 12mo; 10. *Histoire Ecclésiastique*, Paris, 1691 and the following years, in 20 vols. 4to, continued by Père Fabre, of the Oratory, Paris, 1726 and the following years, in 16 vols. 4to, making in all 36 vols. 4to; 11. *Discours sur l'Histoire Ecclésiastique*, Paris, 1802, in 8vo; 12. *Discours sur les Libertés de l'Eglise Gallicane*, 1724. Besides these works, the Abbé Fleury was also the author of the following, viz. 1. *Discours sur la Prédication*, 1773, in 12mo; 2. *Traité du Droit publique de France*, 1769, in 4 vols. 12mo; 3. *Le Soldat Chrétien*, 1772, in 12mo; 3. *Lettres à Santeul, et deux Lettres en vers Latins*; 4. *Discours sur la Poésie et notamment sur celle des Hébreux*; 5. *Portrait du Duc de Bourgagne, et Avis pour ce Prince*; 6. *Réflexions sur Machiavel*; 7. *Lettres sur la Justice*; 8. *Pensées tirées de Saint-Augustin*; 9. *Mémoires pour le Roi d'Espagne*; 10. *Discours Académiques*. All the works of the Abbé Fleury, with the exception of the Ecclesiastical History, were collected by Rondet, under the titles of *Opuscules*, Nismes, 1780, in 5 vols. 8vo; but M. Emery, superior-general of the Congregation of Saint-Sulpice, published a volume entitled *Nouveaux Opuscules*, Paris, 1807, in 12mo, containing several unedited pieces, some of them possessing considerable merit.

FLEURUS, a small town of the province of West Flanders, in the circle of Charleroy, containing 600 inhabitants, and remarkable for the battles fought there in 1622, 1690, 1794, and 1815, though the last is more frequently designated the battle of Ligny.

FLEXIBLE, in *Physics*, a term applied to bodies capable of being bent or deflected from their natural figure or direction.

FLEXOR, in *Anatomy*, a name applied to several muscles, which are so called from their office, which is to bend the parts to which they belong, in opposition to the *extensors*, which open or stretch them.

FLINDERS ISLAND, is an island in the form of an irregular quadrangle of from three to five miles each side on the south coast of New Holland. Seals are numerous on the beach, and a species of kangaroo not larger than a cat is also found there. Long. 134. 27. E. Lat. 33. 41. S.

FLINT, a mineral which is principally composed of silica. See MINERALOGY.

FLINT, the county town of Flintshire, in North Wales, 204 miles from London, on the river Dee. It is an ancient corporation, and, in conjunction with the boroughs of Rhyddlan, Overton, Caerwys, and Caergoety, returns one member to the House of Commons. It is resorted to in summer for sea-bathing. Though the assizes are held at Mold, the county jail is at Flint. The population amounted in 1801 to 1169, in 1811 to 1433, in 1821 to 1612, and in 1831 to 2216.

FLINTSHIRE, a county of North Wales. It consists of a narrow tract of land, about twenty-eight miles in length, but varying considerably in its breadth, though in no part exceeding ten miles. The Irish Sea partly bounds it on the north; the river Dee and part of Cheshire on the north and north-east side; and the county of Denbigh on the south and west sides. A portion of the county is detached from the rest by the interposition of a part of Denbighshire. It is divided into five hundreds, viz. Coleshill, Maylor, Mold, Prestatyn, and Rhyddlan. The river Dee formerly washed the walls of the ancient castle of Flint, the county town, but has of late considerably receded, and it has now no means of carrying on commerce by sea, except in very small vessels; and it is necessary that those should be so constructed as to remain dry, during low water, without injury. Mold, the town at which the assizes are held, has rapidly increased, owing in some measure to the establishment of very extensive mills for spinning cotton in its vicinity. The city of St Asaph is neither distinguished by its extent nor the beauty of its buildings. Its situation, on the side of a hill, the summit of which is crowned by the cathedral, and between the rivers Clwyd and Elwy, is very imposing, and strikes the traveller forcibly as he approaches it. Though the immediate vicinity of this city has a sterile appearance, yet the views near it in one direction over the enchanting vale of Clwyd, and in another over the diversified landscape which terminates with the ruins of the castle of Denbigh, present to the eye of those who have a taste for beautiful scenery a most delightful treat.

The diocese of St Asaph extends nearly over the whole of the county, and, from several livings which are held *in commendam* by the bishop, is a very lucrative preferment. The Episcopal chair has, since the Reformation, been filled by many prelates of most distinguished character. Morgan was translated to this see in 1601, as a reward for his eminent acquirements as an oriental linguist. He was employed in translating the sacred writings into the Welsh language, as well as in a part of the English edition commonly called Queen Elizabeth's Bible. Dr Isaac Barrow, uncle to the celebrated mathematician, was eminent for his munificence to the see, as well as for his profound learning. The pious Beveridge, during a few of his last years, was bishop of St Asaph; and the chair has been since filled by the amiable and learned Shipley, and the powerful and energetic Horsley. The cathedral has been of late much improved and beautified by the bounty of Bishop Bagot, and the liberal contributions of the nobility and gentry of the county. It was built about the year 1480, upon a foundation of much more ancient date; it is in length from east to west 179 feet, and in breadth from north to south 108 feet. The most important place in this county, from its wealth, its population, and its continued increase, is the town of Holywell, deriving its name from the well of St Wenefrede, which, in the ages of credulity, was supposed to possess miraculous powers of healing, but has of late been applied to better purposes than nurturing such superstitions. As there are many Catholics in Flintshire, the belief in the miraculous power of this spring is not wholly extinct, nor have the pilgrimages to it altogether ceased. So late as 1805, indeed, a very zealous attempt was made to revive the credit of the saint, and establish faith in the wonderful cures achieved by bathing in her well. A case was narrated, accompanied with certificates, and a challenge given to all who doubted of the miracle, by an appeal to facts which, however it might confirm the faith of the saint's votaries, had no influence beyond that narrow circle.

The productions of Flintshire which deserve most notice are the minerals, the preparation of which gives employment to a considerable share of the population. Coals are found in abundance, chiefly near the banks of the Dee, and in other parts near the surface, and in very thick seams. The city of Chester is principally supplied with its fuel from hence, and considerable quantities were shipped for Ireland before the change in the course of the Dee, and before the coal mines of Lancashire and Cumberland had attained their present extent. Lead is most copiously raised from a very extensive mining tract near Holywell; and in the same excavations is raised most excellent limestone, applicable to the purposes of agriculture as well as building, and so hard that it will bear a high polish, in fact a kind of marble. Below the limestone is found petrosilex, which is ground and becomes very valuable in the manufacture of earthenware. Calamine is found in considerable quantities; a part is exported, but much is used within the county in the preparation of brass. The lead is divided by the miners into two kinds; that called cubic, or dice ore, is generally used in glazing earthenware; the other, called white, or steel-grained ore, is principally cast into pigs for distant consumption: this latter contains a portion of silver sufficient to defray the expense of separating the metals, and several thousand ounces have been annually extracted. The workmen in the lead mines are visited with maladies which both embitter and shorten their lives.

The manufactories of this county are very considerable, and have taken that course which the natural productions seem to have indicated. Brass is made by the mixture of copper with calamine, and formed into the different shapes to fit it for domestic and commercial purposes. Copper-works, under the Pargs Mine Company, are constructed, and produce large quantities of copper sheathing, bolts, nails, and other necessaries for naval equipment, as well as brass wire and minuter articles. The potteries are very extensive, and manufacture large quantities of the inferior kinds of earthenware, which supply the consumption of a great part of Wales, and export considerable quantities to Ireland. Besides those manufactories which the minerals have introduced, the fine stream that issues from the well of St Wenefrede has attracted the attention of cotton-spinners, who have erected a most powerful mass of machinery. They carry on the operations of carding and spinning cotton to a great extent.

The agriculture of this county is in a neglected state, drawing to it a very insufficient portion of its capital; and hence few improvements have been adopted of late years. Near the banks of the Dee there is some good corn land, of a clayey texture, on which, after a fallow, good wheat is grown. The meadows in this part produce excellent herbage, and the cows afford the best possible butter. The northern part of the county is generally a level country, and well calculated for the growth of wheat, oats, and beans. On the higher lands rye is cultivated, but those lands are very imperfectly tilled, and nearly destitute of manure. The rich vale of Mold forms a striking contrast with the more mountainous parts of the county, and yields very good butter, corn, and meat.

The ruins of ancient edifices, and other antiquities, are numerous, and invite the attention of the antiquarian. A few years ago, whilst digging for the purpose of laying the foundation of a copper work, a Roman *hypocaust*, or hot bath, was discovered, furnished with numerous flues, covered with tiles of a red colour; a clear evidence that the county had been anciently inhabited by some persons acquainted with the luxuries of Rome.

Few counties, in proportion to their extent, contain so many gentlemen's seats as Flintshire. The most remarkable are, Mostyn Hall, Sir Thomas Mostyn; Pengewern, Sir Edward Pryce Lloyd; Boddlewyddan, Sir John Williams; Kinmael Hall, Reverend Edward Hughes; Gwernhailed, Philip Lloyd Fletcher, Esq.; Hanmer Hall, Sir Thomas Hanmer; Downing, David Pennant, Esq.; Halken, Earl Grosvenor; Adwynt, J. Roberts, Esq.; Llewenny Hall, Lord Kirkwall.

The following are the returns of the population for the years ending 1811, 1821, and 1831.

YEARS.	HOUSES.			OCCUPATIONS.			PERSONS.		
	Inhabited.	By how many Families occupied.	Uninhabited.	Families chiefly employed in Agriculture.	Families chiefly employed in Trade, Manufactures, or Handicraft.	All other Families not comprised in the two preceding classes.	Males.	Females.	Total of Persons.
1811	8816	9740	155	4086	3009	2645	22,712	23,806	46,518
1821	9973	10,611	147	4421	3531	2659	26,733	27,051	53,784
1831	...	...	...	...	...	...	29,924	30,088	60,012

See *Agricultural Survey of North Wales;* Wynne's *History of Wales;* Aikin's *Tour in North Wales.* (G.)

FLIP, a sort of drink, composed of malt liquor, brandy, and sugar, and in great favour among sailors.

FLOAT, a certain quantity of timber bound together with rafters athwart, and put into a river to be conveyed down the stream.

FLOATING BODIES are those which swim on the surface of a fluid, the most interesting of which are ships and vessels employed in commerce and war. See SHIP-BUILDING.

FLOOD, a deluge or inundation of waters. See the article DELUGE.

FLOOD is also used in speaking of the tide. When the water is at the lowest, it is called *ebb;* when rising, *young flood;* when at the highest, *high flood;* when beginning to fall, *ebb water.*

FLOOD-mark, the mark which the sea makes on the shore at flowing water and the highest tide. It is also called *high-water mark.*

FLOOR, in building, the underside of a room, or that part which we walk on. See BUILDING.

FLORA, the reputed goddess of flowers, was, according to Lactantius, only a lady of pleasure, who having gained large sums of money by prostituting her person, made the Roman people her heir, on condition that certain games called *Floralia* might be annually celebrated on her birthday. Some time afterwards, however, such a foundation appearing unworthy the majesty of the Roman people, the senate, in order to ennoble the ceremony, converted Flora into a goddess, whom they supposed to preside over flowers, and thus made it a part of religion to render her propitious, that it might be well with their gardens, vineyards, and parterres. But Vossius (*De Idol.* lib. i. c. 12) is by no means disposed to allow the goddess Flora to have been the courtezan above mentioned; he contends that she was a Sabine deity, and thinks that her worship might have commenced under Romulus. His reason is, that Varro, in his fourth book of the Latin tongue, ranks Flora amongst the deities to whom Tatius king of the Sabines offered up vows before he joined battle with the Romans. The goddess Flora was, according to the poets, the wife of Zephyrus. Her image in the temple of Castor and Pollux was dressed in a close habit, with the flowers of peas and beans in the hand; but the modern poets and painters have been more lavish in setting off her charms, considering that no parts of nature offered such innocent and exquisite entertainment, as the beautiful variety which adorns, and the odour which embalms, the floral creation.

FLORAC, an arrondissement of the department of the Lozère, in France, extending over 660 square miles. It is divided into seven cantons, and these into fifty-five communes, containing 43,500 inhabitants. The capital is the town of the same name situated on the river Tornou, which falls into the Tarn. It contains 340 houses, with 2160 inhabitants.

FLORALES Ludi, or Floral Games, in *Antiquity*, were games celebrated in honour of Flora, the goddess of flowers. The *ludi florales*, according to Pliny (lib. xviii. c. 29), were instituted by order of an oracle of the Sibyls, on the 28th of April; not in the year of Rome IↃXVI. as we commonly read it in the ancient editions of that author, nor in IↃXIV. as Hardouin has corrected it, but, as Vossius reads it, in 513; though they were not regularly held every year till after 580. They were chiefly held in the night time, in the patrician street; but some will have it there was a circus for the purpose on the hill called Hortulorum.

FLORALIA, in *Antiquity*, a general name for the feasts, games, and other ceremonies, held in honour of the goddess Flora.

FLORENCE, a city, the capital of the grand duchy of Tuscany, and of the division of it of the same name. The department of Florence comprehends the extensive valley of the Arno, and a great portion of the Appennine Mountains, and extends over 3652 square miles, divided into thirty-three vicariates, and containing 643,385 inhabitants. The city of Florence is at the foot of the Appennines, in a beautiful and fertile valley, and is watered by the Arno, which divides it into two unequal parts. It is surrounded with fortifications, but of no great military strength. It has seven gates, of which that of St Gallo is distinguished by a noble marble triumphal entrance. It is divided into four wards, and contains seventeen piazzas, 172 churches, twelve hospitals, many noble private palaces, 9000 dwellings, and 75,200 inhabitants. The streets are not altogether regular or wide, but they are kept clean, are well paved, and lighted by night. The Via Larga is distinguished by many large and magnificent palaces; but the Corso, in which races are held, is the favourite promenade of the fashionable people. The finest view of the city is, however, to be seen from the piazza of Santa Maria to the palace Pitti, the grand ducal residence. The cathedral, the galleries, the churches, the obelisks, and the fountains, are the most magnificent of any in Italy, and deserve a description more detailed than the compass of this notice will allow. The institutions for charity, and the establishments for instruction, especially in the fine arts, are upon an extensive and liberal plan. There are three public libraries; the Laurenziana with 120,000 volumes, the Machlibecchiana with 90,000, and the Marcelliana with 40,000. Florence was formerly one of the most distinguished manufacturing places of Italy, and the various kinds of silk goods and of fine black cloth there produced still maintain a high reputation. Besides these, it produces table and other linen, woollen cloths, carpets, caps, soap, perfumery, and essences, lacquered and silvered ware, and many works in alabaster and marble. Florence has produced many individuals eminent in arts, science, and literature; among others, Machiavelli the political writer; Dante Allighieri, Luigi Rucellai, Menzini, and Filicaja, poets; Guicciardini the historian, Michel Angelo Buonarotti the artist, Galileo the astronomer, Amerigo Vespuccio the navigator, Lully the musician, and the artists of the school of this city. It is in long. 11. 0. 25. E. lat. 43. 46. 30. N.

Florence, an ancient piece of English gold coin. Every pound weight of standard gold was ordained to be coined into fifty Florences, to be current at six shillings each; or into a proportionate number of half Florences, or quarter pieces, by indenture of the mint. See 18 Edw. III.

FLORES, or Ende, an island in the Eastern Seas, extending about 200 miles in length by forty or fifty in breadth, at the extremity of which is a strait called Flores Strait. Near the coast is a fine open country, but the interior parts are mountainous and woody; and there is said to be a volcano in the centre. Sandal wood was formerly obtained here in great abundance, but it is now grown scarce. At a village in the straits which separate Flores from Sabraon and Solor, European vessels procure refreshments in exchange for ammunition, coarse cutlery, and other articles. The island belongs to the sultan of Beema, in the island of Sambawa, who derives a considerable revenue from the edible bird-nests found in it. The Portuguese formerly resided in it; and their descendants, or those calling themselves such, and professing the Roman catholic religion, are still dispersed over the island. The island is situated between the 120th and 123d degrees of east longitude, and the 8th and 9th degrees of south latitude.

FLORIDA, a country of North America, now belonging to the United States. It is about 450 miles in length, and has an average breadth of about 120 miles. It is comprehended between the parallels of 80. 25. and 87. 20. W. long. and 25. and 31. N. lat. Formerly it was separated into two political divisions, whose geographical limits were strongly marked by nature, viz. East and West Florida. But this division has ceased to exist, and the two Floridas now constitute one government. It is bounded on the north by Alabama and Georgia, on the east by the Atlantic Ocean, and on the south and west by the Gulf of Mexico. The northern part of the western boundary is formed by the river Perdido, which separates it from Alabama. Florida formerly extended as far west as the Mississippi, the northern boundary being formed by St Mary's River from the ocean to its source, thence by a right line to the point where Flint River unites with the Appalachicola, thence up the Appalachicola to the parallel of lat. 31. N. and thence due west on that parallel to the Mississippi. The part lying between the Mississippi and Pearl River is now included in the state of Louisiana; and the part between the Pearl and the Perdido, in the states of Mississippi and Alabama. The part east of the Perdido is under the territorial government of Florida. It is supposed that this country contains about twenty-four millions of acres of marketable land.

It is now generally admitted that Florida was discovered in 1497 by Sebastian Cabot. In 1512, however, it was more fully explored by the Spaniards under Juan Ponce de Leon, who gave this region its name from *Pasqua Florida*, or Palm Sunday, probably the day on which land was descried. For a long time the name was general, in Spanish works, for the whole Atlantic coast of North America. The first effectual settlement of the country was made in 1524. Four years afterwards an expedition was undertaken by Pamphilo de Narvaez, with 400 men, from the island of Cuba. He penetrated into the interior of the country, but was never heard of more. In 1538 Florida was entirely subdued by Fernan de Soto, an officer in the Spanish service, after a long and bloody struggle with the natives. In 1564 the French also obtained a footing in the country, owing to the facility with which they gained the good will of the natives, and the readiness which the latter displayed in assisting them against the Spaniards. They formed little settlements along the shore, but these were ultimately destroyed by the Spaniards. In 1597 the French made severe reprisals against their European enemies, but from this time they abandoned their settlements in this part of North America. In 1586 the town of St Augustine was attacked and pillaged by Sir Francis Drake; and in 1665 it was also entered and plundered by a body of bucanneers under Captain Davis. In 1702, Colonel More, with a body of troops, besieged this town for three months; but the Spaniards having come to its relief, he was compelled to retreat. Another attempt to take St Augustine was made in 1740, but without success. In 1763 Florida was ceded to Britain by Spain, which received Havannah in exchange. The British government gave great encouragement to agriculture, and numerous colonists poured into the country from various parts of Europe, as well as from Great Britain. This is regarded as the most flourishing period in its history. It was, however, by a well-concerted scheme of the Spaniards, reconquered in 1781, and guaranteed to them by the peace of 1783. In 1819 negotiations were commenced between the United States and Spain, for the cession of Florida to the former; and a treaty to that effect was entered into. This treaty was ratified shortly afterwards, and in July 1821 Florida was finally taken possession of by General Jackson, by order of the government of the United States, to which it now entirely belongs.

As the whole province is a peninsula, it presents an extended point to the sea, and from its position, as well as its formation, is calculated, when peopled, to enjoy a considerable share of navigation; but the want of secure bays and harbours, and the dangerous bars at the mouths of its rivers, will prevent any sanguine expectations of its speedy pre-eminence from being realized.

From the uncommon flatness of the country on the sea shore, and from its being intersected by numerous rivers, there is perhaps no part of the world of the same extent which has so many inlets, sounds, narrow passes of water between the islands, and communications of one point of the shore with another by means of inland channels. The whole coast is almost a continued line of these sounds; and it is contemplated that, at a comparatively small expense, a canal, communicating with the sea in a hundred places, might be made from New Orleans to the river St Mary. Almost all the rivers, before discharging themselves into the gulf, spread into broad lakes, which are frequently joined by a natural canal, containing from four to six feet of water. Perdido Bay, which divides Alabama from Florida, is thirty miles in length and from two to six in breadth. Pensacola Bay is of about the same length, but of greater breadth; it receives several rivers, and affords the best harbour on the whole shores of the gulf. Chactawhatchee Bay is forty miles in length, and from seven to fifteen in breadth. It is connected with Pensacola Bay by St Rosa Sound, a fine sheet of water, about forty miles in length and from one and a half to two miles in breadth. There are a number of other bays, but of smaller dimensions than those above mentioned.

All the rivers which have long courses rise in the high lands of Georgia, Alabama, and Mississippi. St Marys, which is for a long way the separating line between Florida and Georgia, is a very considerable stream, which falls into the Atlantic by a broad mouth, but is only navigable for a short distance. St John's is also a large river; it rises in the centre of the peninsula, and flowing with a gentle current in a northerly direction, spreads into a wide channel, and passes through several lakes, the largest of which, St George, is twenty miles long and twelve broad, and finally falls into the sea forty miles to the south of St George. It has been navigated by a steam-boat. Most of the rivers which fall into the gulf have their sources in Georgia. The most important of these is Appalachicola, which divides East from West Florida. It is formed by the conjunction of two considerable streams, and is the longest, largest, and most important river in Florida. Besides those above mentioned, there are a great number of other rivers which fall into the gulf at different points. Indeed the whole country is intersected by them, and so furnished with inlets, and level in the soil, that there is no part of the territory at any considerable distance from water communication. The value of the rivers, however, is considerably depreciated by most of them having a bar at their mouth, which prevents vessels drawing much water from entering. But schooner and steam-boat navigation is practicable to a considerable extent.

The sea islands on the Florida shore are not of much importance. St Rosa island is a long and narrow slip parallel to the coast, between St Rosa Bay and Pensacola. The Tortugas are a group of islands opposite the southernmost point of East Florida; they are covered with mangrove bushes, and extend from north-east to south-west. Anastasia, which is opposite to St Augustine, and divided from the mainland by a narrow channel, is twenty-five miles in length. They are covered with pine trees and sand banks, and have a sterile soil. On the West Florida shore are Hummoch, Crooked, St Vincent's, St George's, Dog, and James' Islands.

There are a vast number of springs, fountains, and lakes in Florida. The subterranean waters frequently burst forth in the form of vast boiling springs, which form rivers at a short distance from their outlets, and by their frequency, their singular forms, the transparency of their waters, and the multitude of their fishes, constitute one of the most striking curiosities of the country. There is a spring or outlet of immense size situated about twelve miles from Tallahasse. It has a depth of about two hundred and fifty fathoms. The waters, like those of the gulf, have a cerulean tinge, and are of aerial transparency. Amongst the other curiosities of Florida may be mentioned a number of natural caverns and bridges, some of which are of considerable dimensions. The antiquities consist of great roads, causeways, forts, and other indications of former occupation.

The climate of Florida may be considered as in some respects tropical, but the northern belt of country, which lies along the southern limits of Georgia and Alabama, partakes of the cooler temperature of those states, and is remarkably salubrious. The regular range of the thermometer throughout Florida, from June to the autumnal equinox, is between eighty-four and eighty-eight degrees of Fahrenheit. The mercury occasionally rises to above 100°, but this seldom occurs. There is generally a sky of mild azure, a southern breeze, and an air of great purity; but even in winter the influence of the unclouded and almost vertical sun is uncomfortable. The evening air, however, is very humid, and the dews are excessive. In the peninsular parts there are sometimes slight frosts, but water seldom or never freezes. The most delicate orange trees bear fruit in full perfection, and of a delicious quality. The rainy season commences only in winter, and the sultry season begins in June and ends with the autumnal equinox. The peninsular parts being nearer the tropics, have a higher temperature than West Florida, which is occasionally fanned by Canadian breezes, sweeping the valley of the Mississippi. Like the West Indies, the peninsula is subject to tornados; and during the autumnal equinox hurricanes and destructive gales sometimes occur. There are in particular seasons indications of considerable humidity over the whole country; and the same sudden variations of temperature which constitute so distinct a feature in all the south-western parts of the United States are experienced here. The unremitting heat which prevails, and the frequent rains which fall from June to October, are apt to generate the fevers of southern climates, especially in places which lie in the vicinity of ponds and marshes. On the other hand, it may be safely asserted that those parts of Florida which are removed from swamps and other stagnant waters are healthy.

The lands of Florida, in their general character, are light and sandy; and they are represented as not capable of sustaining a continual succession of exhausting crops. Considerable tracts in different parts are fertile; but by far the greater part is sterile or unproductive. The lands have been divided into seven varieties: 1. *Pine Barrens*, which constitute a great part of the country. They produce vast quantities of yellow and pitch pine; also shrubs in great variety, and a wiry grass, which yields sustenance to numerous herds of cattle. In wet seasons, orchards of peach and mulberry trees flourish remarkably well on these lands. 2. *Hammock Land*. This variety, which constitutes the main body of good land, is so called because it rises in mounts or small tufts among the pines. Most of the islands remote from the sea are of this kind, which is adapted to sugar cane, cotton, indigo, potatoes, and pulse. 3. *Prairies*. These are of two kinds; one of them, found in the pine barrens, has a covering of sand, and is sterile; and the other, which is covered with wild grass, is met with on high lands. 4. *Swamps*. These are of two kinds, the river and inland swamps; the latter are the most valuable, producing rich crops of rice, and, in some instances, the best cotton, corn, and indigo, in the country. 5. *Marshes*, some of which are covered with salt water, and others with fresh. The fresh-water marshes produce an abundance of wild oats. 6. A species of marsh called *Gallen*, consisting of water courses covered with strong earth, which trembles like jelly when touched. 7. Elevated grounds covered with large trees of different species.

Florida is not rich in minerals, although it is affirmed that several kinds of precious stones have been found in it. Pit coal, iron ore, and ochres of different colours, are, however, abundant.

The vegetable kingdom in Florida displays greater variety than is to be found in any other part of the United States. In the hammock lands, on the river courses, and in the richer swamps, nothing can surpass the luxuriance and splendour of the trees and shrubs. Ever verdant forests of pine cover a great extent of country, and the trees are of uncommon height and beauty. What are called white cedar and cypress abound in the swamps, and they grow to an enormous size. Oaks are also numerous, and the tree here developes itself in full perfection. After the union of Florida with the United States, a plantation of oaks was commenced at Deer Point, and in 1829 upwards of 76,000 were growing in a flourishing condition. The cabbage palm, or *chœmarops palmetto*, is common, and grows to a great height. The leaves of this superb tree are manufactured into hats, baskets, and mats. In the deep swamps immeasurable cypress trees shoot up in straight columns, the foliage of which is closely interwoven at the top, forming a canopy of verdure of vast extent. On the hammock lands, the beautiful dog-wood trees spread their horizontal branches, which, interlacing each other, form a fine deep shade, impervious to the rays of the sun, and surpassing the growth of all vegetation underneath. Here also may be seen the beautiful pawpaw, which has a stem perfectly straight, smooth, and silver-coloured, with a conical top of evergreen foliage, and fruit of the richest appearance. Titi is the name of a shrub which fills the southern swamps, as the elder does those of the north. It flowers in masses of white ornamental blossoms, and has singular strings of covered seeds, which hang on the bushes till winter. Five or six species of pine are found here. The southern extremity of Florida is very rocky. Instead of the trees and shrubs which are found in the rest of the country, it is covered with mastic, lignumvitæ, gum elemy, ovino, wild fig, and mangrove.

There are many traces of ruined towers and Indian villages, together with other indications of former occupation; and wherever these are discovered, there may also be seen those groves of lime, orange, peach, and fig trees, which are spoken of by travellers as having been found here indigenous to the soil. Wild grape vines abound. *Myrica odorata*, or candle berry laurel, is common; and from the berries of this plant an excellent kind of wax for candles is prepared. Among other flowers is found the magnificent *Hybiscus*, which, though an herbaceous and annual plant, grows to the height of ten feet, branching regularly in the form of a sharp cone. It is covered with large crimson flowers, which unfold in succession during the whole of the summer months. *Tillandsia usneoides*, long moss or Spanish beard, is common here. It hangs down in festoons, sometimes from ten to fifteen feet in length, like the pendent stems of the weeping willow. The fibre, when properly prepared, is elastic and incorruptible, and in many respects resembles horse hair, both in appearance and use. It is used for stuffing cushions, saddles, and the like.

The low savannahs are covered, like the prairies of the upper country, with a prodigious growth of grass and flowers. In the swamps, the cane brakes are of great height and thickness, and the rushes, and other meadow plants, grow to an uncommon size. Some of the reed canes are seen from thirty to forty feet in height. The lakes and creeping bayous, especially in summer, are covered with a curious species of aquatic plant, called by botanists *pistia stratiotes*. It somewhat resembles the vegetable commonly called house-leek, and has a beautiful elliptical leaf. When the roots of thousands of these plants have twined together, so as to form a large and compact surface, the mass is often drifted by the wind or current to a considerable distance, and thus presents the appearance of a floating island of considerable extent. The herbarium of this country is exceedingly rich and diversified. The cultivated vegetables are, maize, beans, potatoes, especially sweet potatoes, pumpkins, melons, rice, and a variety of esculent roots, particularly a species of *arum*, which is not cultivated in the maritime parts. It has a large bulbous root, which, when roasted or boiled, has a taste similar to the yam. The pistache is a kind of nut in pods, which grows abundantly in sandy land. It is much cultivated both by the Seminoles (an Indian tribe) and by the Americans. It is baked or roasted in the shell, and used by confectioners as a sweetmeat. Tobacco, cotton, indigo, rice, and the sugar cane, will in future be the principal articles of culture. The African and Otaheite cane flourish remarkably well in the southern parts of the country, and planters are beginning to turn their attention to the cultivation of them. The coffee-tree has been tried on the peninsula; and coffee can unquestionably be raised there, but whether of a kind or in quantities which will justify an extensive cultivation of the article, has not yet been sufficiently proved. The olive, it has been found, flourishes here, and bears well. A species of cactus, on which the cochineal fly feeds, is common in the country. This plant, it is conjectured, will become an important article of manufacture. A species of cabinet wood of great beauty called bastard mahogany is also found here.

Florida is an admirable country for raising stock, and formerly the rearing of cattle and horses was the chief employment of the small planters. Deer are very abundant, and hunting is pursued to a considerable extent, although the Indians complain of the scarcity of game. Wolves sometimes assemble in great numbers, and, whether united or single, they are always formidable enemies to the folds and vacheries of the planters. Bears are still found here, and their flesh is esteemed a luxury by the inhabitants. The other quadrupeds of Florida are, wild cats, panthers, foxes, rabbits, many beautiful kinds of squirrels, raccoons, Mexican oppossums, and wood-cocks.

The ornithology of Florida is probably the richest in North America. The variety and splendour of the birds is one of the most striking features of the country. Those of the aquatic species are immensely numerous, especially during winter. In the woods are vultures, hawks, rooks, jays, parroquets, wood-peckers, pigeons, turkeys, herons, cranes, curlews, cormorants, plovers, blue birds, mocking-birds, red birds, and great varieties of the sparrow tribes. The dog-wood groves are the resort of vast numbers of the small singing birds. Among the remarkable specimens of the feathered tribes are the snake birds, a species of cormorant of great beauty. Wild ducks and wild geese are found in prodigious flights; wild turkeys are plentiful, and of a very large size.

The sea coasts, the rivers, and the lakes, abound with every variety of fish, and furnish food to the greater proportion of the people, especially on fast days and in Lent. The rivers and lakes swarm with alligators, who feed most voraciously on the innumerable fry of smaller fish. The abundance of these smaller fish is a most singular fact. The sea-shore abounds with sharks, which, like the alligators, find a supply of food by preying on the smaller tribes, which, when pursued by those voracious monsters, ascend the creeks to parts where they suddenly contract, and so fill the water as to impede the passage of a boat. In some instances, where the contraction of the stream is very sudden and very great, those smaller fish have been seen so closely crowded as to become a mass actually filling the channel, and even rising, wedged together, above the surface of the water.

Various kinds of serpents are common in Florida, and incredible numbers of the small insects called ephemeræ cover the surfaces of the lakes and rivers, supplying abundant food for the birds, frogs, and fishes. Gnats, mosquitos, and other insects, also abound, and in some parts are extremely annoying.

This country was, in some respects, an invaluable acquisition to the United States. Besides its political importance, it was necessary to them on account of its harbours, its immense line of coast, and its inexhaustible supplies of ship timber. From the period of the incorporation of Florida with the North American States, emigration to this state has been considerable. It has been divided into counties, judicial and military districts; and the benefits of American institutions have been diffused over its whole extent. The present number of inhabitants is estimated at about 35,000. They comprehend emigrants from all countries, and from every American state, and they are as thoroughly mixed as any community in the United States. Almost all the inhabitants are poor, and too great a proportion of the recent emigrants consists of mere adventurers. Most of the ancient inhabitants lead a pastoral life, and subsist by the rearing of cattle. A few of the planters are opulent, and possess good houses, which are generally situated in remote forests and savannahs. They are said to be remarkable for their hospitality to strangers.

Of the Indians, which were formerly so numerous and powerful in this country, only a few small fragments of tribes remain, which, with refugees from other tribes, are dispersed throughout the forests and savannahs. The Indians of this region are an alert, active, and athletic people; of joyous dispositions, and fond of war. They have the common propensity for intoxicating liquor, and for gambling. As hunters they are expert; and by the sale of bear, deer, panther, and wolf skins, of horses and cattle, bees' wax, honey, venison, and such articles as are the produce of the chase, they procure the necessaries of life.

The chief town of East Florida, and the most populous in the country, is St Augustine. It is situated on the Atlantic coast, thirty miles below the mouth of St Johns, on an inlet behind the island of St Anastasia, in north lat. 29. 45. It is about two miles within the bar, which has only from eight to ten feet of water, thus precluding the entrance of large vessels into the harbour. The town is built of an oblong form; it is surrounded by a ditch, fortified by bastions, and defended by a castle called Fort St John. The river St Mark flows through the harbour, and divides the town from the island. The streets are in general narrow; the houses are not more than two stories high, with thick walls, spacious entries, large doors, windows, and balconies, and having commonly a fine garden attached to them. Although the soil around St Augustine is so sandy as to have the appearance of being sterile, yet it is productive to a considerable extent. It yields two crops of maize yearly, and garden vegetables are reared in abundance. The orange and lemon arrive at great perfection here; the palm or date tree grows near to the town, and the olive has become naturalized in the soil. The population of St Augustine consists of between 4000 and 5000 inhabitants. The capital of West Florida is Pensacola, which is situated on a bay of the same name, in long. 87. 12. W. and lat. 30. 20. N. The shore is low and sandy, but the town is built on a gentle ascent. Like St Augustine, it is of an oblong form, and nearly a mile in length. Small vessels only can come close up to the town; but the bay affords one of the safest and most capacious places of shelter for shipping in the Gulf of Mexico. This town has been selected by the American government as a naval station and depôt, for which it is admirably adapted. Pensacola has increased in prosperity since its union with the United States, and at present contains about 3000 inhabitants.

The seat of government for the territory of Florida is Tallahasse. The position of this town was fixed upon in 1824, and in the year following it was divided into lots, and immediately incorporated as a city. The situation of Tallahasse is remarkably pleasant, and is supposed to be healthy. The ground on which it stands is considerably elevated, and the surrounding country is high. An elevated chain of hills bounds the shores of the Mexican Gulf, and the town lies three miles north of this ridge, in long. 84. 36. W. and lat. 30. 28. N. The country around is generally fertile, and suited to the cultivation of sugar. At present it is covered with various kinds of trees, amongst which is an excellent kind of mahogany. In 1830 the population amounted to about 1200. St Marks, an inconsiderable place, situated at the distance of nine miles from Tallahasse, is the nearest sea-port. The other towns, villages, &c. of this territory are too insignificant to require a separate description.

It is contemplated to cut a canal through Florida, which, when accomplished, will develope its resources, and cause the country to present many attractions to the emigrant. Upon this subject Mr Flint observes, "As an agricultural country, it must be confessed, a great part of Florida is sterile. The level pine forest lands will bring one or two crops of corn without manure; and will probably be cultivated to a certain extent with indigo. The drier lands of this sort are admirable for sweet potatoes, and on the whole better, with the requisite cultivation and manuring, for gardens, than soils naturally more fertile. There are considerable bodies of excellent land distributed at wide intervals over all the country; but a small proportion of these are what are denominated first rate. Some parts, probably, offer equal advantages for the cultivation of sugar with the sugar lands of Louisiana. Cochineal, it is supposed, will be made to advantage, and, it may be, coffee. It offers superior maritime advantages of every sort; abounds in the materials of ship-building; and, in its rich and inexhaustible fisheries, and its supply of oysters and sea fowl, has its own peculiar advantages. The immigrant, who sought to enrich himself by cultivation alone would probably make his way to the richer soils west of the Mississippi. But, if taken as a whole, it is more sterile than the country along the Mississippi, it feels the refreshing coolness of the sea breeze and the trade winds, and it is beyond a doubt more healthy."

The counties and chief towns, besides those already mentioned, are, Alachua, *Dell;* Duval, *Jacksonville;* Escambia, *Pensacola;* Hamilton, *Miccotown;* Jackson, *Marianna;* Jefferson, *Monticello;* Leon, *Tallahasse*, 896 miles from Washington; Madison, *Hickstown;* Monro, *Key West;* Moscheto, *Tomoka;* Nassau, *Ferdinanda;* St Johns, *St Augustine*, 841 miles from Washington, 292 south-east from Tallahasse; Walton, *Aliqua;* Washington, *Holme's Valley*. There are also Gadsden, Fayette, and some other new counties.

FLORILEGIUM, FLORILEGE, a name given by the Latins to what the Greeks call *ανθολογιον*, *anthology*, a collection of choice pieces, containing the finest and brightest things of their kind.

FLORILEGE is also particularly used for a kind of breviary, in the Eastern church, compiled by Arcadius, for the convenience of the Greek priests and monks. The florilegium contains the general rubrics, psalter, canticles, the horologium, and the office of the feriæ.

FLORIN is sometimes used to signify a coin, and sometimes a money of account. Florin, as a coin, is of different values, according to the different metals, and different countries where it is struck. See MONEY.

FLORINIANI, or FLORIANI, a sect of heretics of the second century, so denominated from its author Florinus, or Florianus, a priest of the Roman Catholic church, deposed along with Blastus for his errors. Florinus had, along with Irenæus, been a disciple of St Polycarp. He made God the author of evil; or rather asserted that the things forbidden by God are not evil, but of his own appointment. The Floriani had also other names given them. Philastrius says they were the same with the *Carpophorians;* and they were also called soldiers, *milites quia de militaribus fuerunt*. St Irenæus calls them *Gnostics;* St Epiphanius, *Phibionites;* and Theodoret, *Barbarites*, on account of the impurities of their lives; whilst others call them *Zaccheans*, and *Coddians*.

FLORIS, FRANCIS, an eminent historical painter, was born at Antwerp in 1520. He followed the profession of a statuary till he was twenty years of age, when, preferring painting to sculpture, he entered the school of Lambert Lombard, and afterwards went to Italy, where he completed his studies. The great progress he made procured him much employment on his return, and his countrymen complimented him with the appellation of *the Flemish Raffaelle.* He died in 1570, aged fifty.

FLORIST, a person curious or skilled in flowers, their kinds, names, characters, and culture. It is also applied to an author who writes what is called the flora of any particular place, that is, a catalogue of the plants and trees which are found spontaneously growing there.

FLORUS, LUCIUS ANNÆUS, a Latin historian. Respecting the time when he flourished, and the country from which he sprung, we have no certain information. Some have supposed him to be of Spanish origin, connected with the family of Seneca; others have imagined that he came from Gaul. It has been suggested that he may be the same with Julius Florus Secundus, celebrated by Quintilian for his eloquence; whilst others have ascribed the work which we possess under his name to Lucius Annæus Seneca. But be this as it may, there seems good reason for believing that he lived under Hadrian or Trajan. The work left by him entitled *Epitome de Gestis Romanorum*, in four books, is a summary of Roman history from the building of the city to 29 B. C. (725 U. C.), when Augustus closed the temple of Janus. He does not seem to have followed Livy entirely in his narrative, but to have had recourse to older historians. It can scarcely however be considered as a history; it is rather a panegyric pronounced on the whole conduct of the Roman people, written with great elegance of language, and imbued with a rhetorical spirit. The treatment of the subject is poetical, and far removed from the severe dignity of history. In the language, we have sometimes cause to regret the purity of the Augustan age; but in other respects the style is flowing and eloquent, rising far above the age in which the author must have flourished. The short arguments prefixed to the books of Livy are also ascribed to Florus. The best editions of his work are that of Grævius, *Traject. ad Rhen.* 1680; Leipsic, 1760; Bipont, 1754; Titze, 1819; Amer. Par. 1822. See Titze, *de Flori Ætate*, Linz. 1804.

FLORY, FLOWERY, or FLEURY, in *Heraldry*, a cross which has flowers at the end circumflex and turning down, and which is different from the *potence*, in as much as the latter stretches out more like that which is called *patée*.

FLOTSON, or FLOTSOM. Goods which by shipwreck are lost, and floating upon the sea, are, with jetsom and ligan, generally given to the lord admiral. But this is the case only where the owners of such goods are not known. It is also to be observed that *jetsom* signifies any thing which is cast out of a ship when in danger, and afterwards beat on the shore by the water, notwithstanding which the ship perishes. *Ligan* is where heavy goods are thrown overboard, before the wreck of the ship, and sink to the bottom of the sea.

FLOUNDER, FLUKE, or BUT. See ICHTHYOLOGY.

FLOUR, the meal of wheat-corn, finely ground and sifted.

FLOUR, ST, an arrondissement of the department of Cantal, in France, extending over 660 square miles. It is divided into six cantons and eighty-two communes, and contains 65,079 inhabitants. The capital is a city built on a hill of basalt, 300 feet high, and only accessible on one side, at the foot of which flows the river Dauzan. The streets are paved, and the houses constructed of basalt, which gives the whole a gloomy appearance, and hence the neighbours have named it the black city. It contains 800 houses, and

5687 inhabitants, who are occupied in manufactures of glass, leather, copper, and iron goods, and archil. Long. 3. 0. 19. E. Lat. 45. 1. 58. N.

FLOWER (*Flos*), among botanists and gardeners, the most beautiful part of trees and plants, containing the organs or parts of fructification. Flowers were in great request at the entertainments of the ancients, being provided by the master of the feast, and brought in before the second course; or, as some think, at the beginning of the entertainment.

Preserving of F*lowers*. The method of preserving flowers in their natural beauty throughout the whole year has been much sought after by many. Some have attempted it by gathering them when dry and not too much opened, and burying them in sand; but this, though it preserves their figure well, diminishes the liveliness of their colour. Muntingius prefers the following method: Gather roses, or other flowers, when they are not yet thoroughly open, in the middle of a dry day; fill the vessel with them up to the top, and when full sprinkle them over with some good French wine, with a little salt in it; then set them by in a cellar, tying down the mouth of the pot. After this they may be taken out at pleasure; and, on placing them in the sun, or within reach of the fire, they will open as if growing naturally; and not only will the colour, but the smell also, be preserved.

The flowers of plants are by much the most difficult parts of them to preserve in any tolerable degree of perfection. Of this we have instances in all the collections of dried plants, or *horti sicci*. In these the leaves, stalks, roots, and seeds of the plants, appear very well preserved; the strong texture of such parts making them always retain their natural form, and the colours in many species naturally remaining. But it is very much otherwise in regard to flowers, which are naturally the most beautiful parts of the plants to which they belong; they are however so much injured in the common way of drying, that they not only lose, but change their colours, by which means occasion is given to many errors; and they usually also wither up, so as to lose their very form and natural shape. The primrose and cowslip kinds are instances of the change of colours in the flowers of dried specimens; for those of this class of plants easily dry in their natural state, but they lose their yellow, and, instead of it, acquire a fine green colour, much superior to that of the leaves in their most perfect state. The flowers of all the violet kind lose their beautiful blue, and become of a dead white; so that in dried specimens there is no difference between the blue-flowered violet and the white-flowered kinds.

Sir Robert Southwell has communicated to the world a method of drying plants, by which this defect is proposed to be in a great measure remedied, and all flowers preserved in their natural shape, and many in their natural colours. For this purpose two plates of iron are prepared of the size of a large half sheet of paper, or larger, for particular occasions. These plates should be made so thick as not to be apt to bend; and there must be a hole made near every corner for receiving a screw to fasten them closely together. When the plates are prepared, have in readiness several sheets of paper, and then gather the plants with their flowers when they are quite perfect. Let this be always done in the middle of a dry day; and then place the plant and its flower on one of the sheets of paper doubled in half, spreading out all the leaves and petals as nicely as possible. If the stalk be thick, it must be pared or cut in two, so that it may lie flat; and if it be woody, it may be peeled, and only the bark left. When the plant is thus expanded, lay round about it some loose leaves and petals of the flower, which may serve to complete any part that is deficient. When all is thus prepared, lay several sheets of paper over the plant, and as many under it; then put the whole between the iron plates, laying the papers smoothly on one, and placing the other equally over them; screw them close, put them into an oven after the bread is drawn, and let them lie there two hours. After this, make a mixture of equal parts of aquafortis and common brandy; shake these well together, and when the flowers are taken out of the pressure of the plates, rub them lightly over with a camel's hair pencil dipped in this liquor; then lay them upon fresh brown paper, and covering them with some other sheets, press them between this and other papers with a handkerchief till the moisture of these liquors is wholly dried away. When the plant is thus far prepared, take the bulk of a nutmeg of gum-dragon, put this into a pint of pure cold water, and let it stand twenty-four hours, in which time it will be wholly dissolved; then dip a fine hair pencil in this liquor, and with it daub over the posterior sides of the leaves, and lay them carefully down on half a sheet of white paper fairly expanded, and press them down with some more papers over these. When the gum water is fixed, let the pressure and paper be removed, and the whole work is finished. The leaves in this case retain their verdure, and the flowers usually preserve their natural colours. Some care, however, must be taken that the heat of the oven be not too great. When the flowers are thick and bulky, some art should be used to pair off their backs, and dispose the petals in a due order; after which, if any of them are wanting, their places may be supplied with some of the supernumerary ones dried on purpose; and if any of them are only faded, it will be prudent to take them away, and lay down others in their stead. The leaves may be also disposed and mended in the same manner.

Another method of preserving both flowers and fruits throughout the whole year is also given by the same author. Take saltpetre one pound, Armenian bole two pounds, clean common sand three pounds, and mix the whole well together. Then gather fruit of any kind that is not fully ripe, with the stalk to each; and put in these, one by one, into a wide-mouthed glass, laying them in good order. Tie over the top with an oil-cloth, carry them into a dry cellar, and set the whole upon a bed of the prepared matter of four inches thick in a box. Fill up the remainder of the box with the same preparation, and let it be four inches thick all over the top of the glass and all round its sides. Flowers are to be preserved in the same sort of glasses, and in the same manner; and they may be taken up after a whole year as plump and fair as when they were buried.

FLUDD, Robert (called in Latin De Fluctibus), a person of some celebrity in his time, was the son of Sir Thomas Fludd, treasurer of war to Queen Elizabeth in France and the Low Countries, and was born at Milgate, Kent, in the year 1574. He received his education at St John's College, Oxford, and afterwards spent six years in travelling through France, Spain, Italy, and Germany. He acquired a strong attachment to the Rosicrucian philosophy, which consisted chiefly of a mystic or cabbalistical jargon, and those who were initiated therein had certain secrets communicated to them analogous to those of freemasonry. On his return home Fludd took the degree of doctor of medicine, settled in the city of London, and became a fellow of the College of Physicians. His piety was of an enthusiastic kind, and the seeming depth of his knowledge gained him much admiration, and procured him temporary celebrity. It is said that he employed a kind of unintelligible cant when speaking to his patients, which sometimes contributed to their recovery, as it operated on their faith, and through it on the imagination. But he is chiefly known as an adept in philosophy, not as a physician. Blending the incomprehensible reveries of the Cabbalists and Paracelsians, he formed a new physical system, replete with mystery and absurdity, and believed in two universal principles, the northern or condensing, and the southern or rarefying power. Innumerable genii, as he conceived, presided over these powers, and committed the charge of diseases to legions of spirits collected from the four winds of heaven. In his estimation, a harmony subsisted between the macrocosm and the microcosm, or the world of nature and the world of man. It is impossible to enumerate all his fancies and whims, which, however absurd and extravagant, being supported by mysterious gravity and the semblance of erudition, attracted the notice of the philosophers of that age. Even Kepler himself thought the preposterous jargon of Fludd worthy of refutation, and Gassendi with the same view wrote his *Examen Philosophiæ Fluddianæ*, 1629. Fludd wrote two books against Mersenne, the first entitled *Sophiæ cum Moria certamen, in quo lapis Lydius, a falso structore Patre Marino Mersenno monacho reprobatus, celeberrima voluminis sui Babylonici in Genesim figmenta accurate examinat*, Francfort, 1629, folio; and the second, *Summum Bonorum, quod est verum Magiæ, Cabalæ, Alchymiæ, Fratrum Roseæ Crucis Verorum, Subjectum*, etc. 1629, folio. His other works were, 1. *Utriusque Cosmi, majoris et minoris, Technica Historia*, Appenheim, 1617, in 2 vols. folio; 2. *Tractatus Apologeticus integritatem Soc. de Rosea Cruce defendens*, Leyden, 1617; 3. *Monochordon Mundi symphoniacum, seu Replicatio ad Apologiam Joannis Kepleri*, Francfort, 1620; 4. *Anatomiæ Theatrum triplici effigie designatum*, ibid. 1623; 5. *Philosophia Sacra et vere Christiana, seu Meteorologia Cosmica*, ibid. 1626; 6. *Medicina Catholica, seu mysticum artis medicandi sacrarium*, ibid. 1626; 7. *Integrum Morborum mysterium*, ibid. 1631; 8. *De Morborum Signis*, ibid. 1631; 9. *Clavis Philosophiæ et Alchymiæ Fluddianæ*, ibid. 1633; 10. *Philosophia Mosaica*, Goudæ, 1638; and, 11. *Pathologia Dæmoniaca*, ibid. 1640.

FLUENT, or Flowing Quantity. See Fluxions.

FLUID, an appellation given to all bodies, the particles of which easily yield to the least pressure or force impressed. See Hydrodynamics.

FLUTE, an instrument of music, the simplest of all those of the wind kind. It is played on by blowing it with the mouth; and the tones or notes are changed by stopping and opening the ventiges arranged along its side. There is a very ancient instrument. It was at first called the flute *a bec*, from *bec*, an old Gaulish word signifying the beak of a bird or fowl, but more especially of a cock; the term *flute a bec* therefore signifies the *beaked flute*, which appears a very proper appellation in comparison with the traverse or German flute. The word *flute* is derived from *fluta*, the Latin for a lamprey or small eel found in the Sicilian Seas, and having seven holes immediately below the gills on each side, the precise number of those in the front of the flute.

By Mersenne this instrument is called the *fistula dulcis seu Anglica;* and, according to him, the lowest note for the treble flute is *C fa ut*, and the compass of the instrument fifteen notes. There is however a flute known by the name of the *concert flute*, the lowest note of which is F. Indeed ever since the introduction of the flute into concerts, the lowest note of the instrument, of what size soever it may be, has been called F; when in truth its pitch is determinable only by its correspondence in respect of acuteness or gravity with one or other of the chords in the *scala maxima* or great system.

Besides the true concert flute, others of a less size were soon introduced into concerts of violins; in which case the method was to write the flute part in a key corresponding to its pitch. This practice was introduced in 1710 by one Woodcock, a celebrated performer on this instrument, and William Babell, organist of the church of All-Hallows, Bread Street, London. They failed, however, in procuring for the flute a reception into concerts of various instruments; for which reason Thomas Stanesby, a curious maker of flutes and other instruments of the like kind, having about the year 1732 adverted to the scale of Mersenne, in which the lowest note is C, invented what he called the *new system*, in which, by making the flute of such a size as to be a fifth above concert pitch, the lowest note became *C sol fa ut*. By this contrivance the necessity of transposing the flute part was taken away; for a flute of this size, adjusted to the system above mentioned, became an octave to the violin. To further this invention of Stanesby's, Louis Merci, performer on the flute, published, about the year 1735, six solos for this instrument, three of which are said to be accommodated to Stanesby's new system; but the German flute had now become a favourite instrument, and Stanesby's ingenuity failed to produce the effect intended. Indeed one great objection against this instrument, which equally affects all perforated pipes, is, that they are never perfectly in tune, or cannot be made to play all their notes with equal exactness. The utmost that the makers of them can do is to tune them to some one key; and to effect this truly, is a matter of no small difficulty. The English flutes made by the younger Stanesby came the nearest to perfection; but those of Bressan, though excellent in their tone, were all too flat in the upper octave. For these reasons some are induced to think that the utmost degree of proficiency on any of those instruments is not worth the labour of attaining it.

German Flute is an instrument entirely different from the common flute. It is not, like the latter, put into the mouth to be played; but the end is stopt with a tompion or plug, and the lower lip is applied to a hole about two inches and a half or three inches distant from the end. This instrument is usually about a foot and a half in length; rather larger at the upper end than the lower; and perforated with holes, besides that for the mouth, the lowest of which is stopped and opened by the little finger pressing on a brass or sometimes a silver key, like those in hautboys, bassoons, and other similar instruments. Its sound is exceedingly sweet and agreeable; and it serves as a treble in a concert.

Flute, or Fluyt, is a kind of long vessel, with flat ribs or floor timbers, round aft, and swelled in the middle, which serves chiefly for carrying provisions in fleets or squadrons of ships, though it is often used in merchandise. The word *flute*, signifying a sort of boat or vessel, is, according to Borel, derived from the ancient *flotte*, a little boat. In the verbal process of the miracles of St Catherine of Sweden, in the twelfth century, we meet with the following words: "Unus equum suum una cum mercibus magni ponderis introduxit super instrumentum de lignis fabricatum, vulgariter dictum *fluta*."

FLUX, in *Medicine*, an extraordinary issue or evacuation of some humour. Fluxes are of different kinds and variously denominated, according to their seats or the humours thus voided; as a flux of the belly, uterine flux, hepatic flux, salival flux, and the like. See Medicine.

Flux, in *Hydrography*, a regular periodical motion of the sea, happening twice in twenty-four hours, in which the water is raised and driven violently against the shores. The flux or flow is one of the motions of the tide; the other, by which the water sinks and retires, is called the reflux or ebb. There is also a kind of rest or cessation of about half an hour between the flux and reflux, during which time the water is at its greatest height, and thence called *high water*. See Tides.

FLUXIONS.

INTRODUCTION.

The calculus of fluxions, the most important addition that ever was made to the fabric of abstract science, was invented in the latter part of the seventeenth century. Considered as a purely intellectual speculation, it far transcends any theory that had been previously known in pure mathematics; and it is not less estimable by reason of its applicability to physical knowledge. By its powers as an instrument of analysis, the science of geometry has been exceedingly enlarged; and the elegant speculations of the ancient geometers now go but a little way into the vast field of knowledge which has been laid open by the fluxional calculus, the sublime discoveries of Apollonius and Archimedes being merely easy deductions from more extended theories. It has, further, rendered most efficient aid in the investigation of the laws of nature, more especially in establishing the true theory of the motions of the heavenly bodies, which, without its assistance, could not have attained its present high position in the scale of human knowledge.

It may easily be supposed that the invention of the calculus was not at once fully revealed to the world. Its principles being inherent in the nature of geometrical magnitude, they would of course be gradually disclosed with the advance of mathematical science.

As long as the geometers of antiquity confined their speculations to the comparison of figures bounded by straight lines, there was no difficulty. The axioms and the mental process of conceiving the magnitudes compared to be placed one upon another, was sufficient to establish the equality of triangles in the cases when these could be brought entirely to coincide. The principle of superposition might have been carried further in the elements, so as to prove the equality of parallelograms, which are the complements of those about the diameter of a parallelogram; also of parallelograms having equal bases and altitudes; and the equality of the square on the hypotenuse of a right angled triangle to the squares on its sides. In fact, the doctrines of plane geometry were sufficient to prove that any two equal rectilineal figures admit always of being decomposed into spaces, such that, corresponding to every space in one of the figures, there may be found a space exactly equal and similar to it in the other figure; so that in this way any two equal rectilineal figures, however dissimilar, may yet, by division, be brought to coincide.

The principle of superposition, which was sufficient for the comparison of rectilineal plane figures, one with another, could not, however, be extended to the comparison of rectilineal with curvilineal, or of curvilineal with curvilineal figures. In treating of these, the ancients found it necessary to introduce new notions and modes of demonstration into geometry; and the difficulty which occurred in reasoning about curvilineal figures gave rise to the method of exhaustions, the most refined and important of their geometrical theories.

The fundamental principle of the method of exhaustions is this very simple proposition, that the difference of any two unequal quantities, by which the greater exceeds the less, may be added to itself so often, as to exceed any finite quantity of the same kind. On this the geometers of antiquity founded their propositions concerning curvilineal figures. By its aid they found that polygons may be inscribed in circles, which shall differ from them by less than any assignable space; and hence they might infer that the circles have to each other the same ratio as similar polygons inscribed in them, namely, the squares of their diameters. Although in this way they could assure themselves of the truth of the propositions, yet as this kind of proof was of a looser nature than that by which they established their more elementary doctrines, they fortified it against all cavil by their usual mode of synthetic demonstration, proving that the square of the diameter of one circle was to that of another as the first circle to a space that was neither less nor greater than the second, and therefore exactly equal to it. By a like process they proved that a cone is one third of a cylinder of the same base and altitude; and from the demonstrations which they gave of these propositions, it might be concluded in general, that when two variable quantities which have a constant ratio approach to two determined quantities, so as to differ at last from them by less than any assignable space, the same constant ratio is also the ratio of the determined quantities, which are the limits of the variable quantities.

Introduction.

The cautious way in which the ancients proceeded in finally establishing the truth of their propositions concerning the proportions of solids, could be of very little use in their original discovery. Indeed we may reasonably suppose, that in the first instance they arrived at a knowledge of their truth by a much shorter road, probably in a way not very different from that followed by the earlier geometers in modern times, who have extended their theories. But whatever path they followed, it led them to some truths of the highest importance at the time they were first known. After ages of fruitless labour in attempting to square the circle, the fine discoveries of Archimedes, that the parabola was two thirds of its circumscribing parallelogram, and the sphere two thirds of its circumscribing cylinder, and its surface four times that of one of its great circles, must have been received by his contemporaries with high satisfaction.

In the beginning of the seventeenth century, the writings of Archimedes greatly engaged the attention of the principal cultivators of mathematical science, who soon seized the spirit of his method, which was altogether distinct from the unwieldy machinery of the ancient mode of synthetic demonstration. He had only considered such solids as could be generated by the revolution of conic sections about an axis, and he had not even exhausted all the cases of these. The celebrated Kepler greatly extended this theory, in a treatise which he composed on the mensuration of round solids. These he conceived to be formed by the revolution of the conic sections about any ordinate, or a tangent to the curve at the vertex, or, in short, about any line whatever within or without the curve. In this way he described about ninety new solids, and proposed them as problems for the consideration of his contemporaries; but of these he resolved only a few of the most simple. In this work he first introduced the name and notion of infinity into the language of geometry. He considered the circle as composed of an infinite number of triangles, having their vertex at the centre, and forming the circumference by their bases. The cone he regarded as composed of an infinite number of pyramids, resting on the infinitely small triangles which formed its circular base, and having their vertices at its vertex; and he supposed a cylinder of the same base and altitude as the cone to be made up of prisms having the same bases and altitudes as those which composed the cone.

The bold extension which Kepler thus gave to the cautious language of geometry drew the attention of his contemporaries, some of whom eagerly followed in his steps. Cavalieri, a friend and disciple of Galileo, embodied the new views in his geometry of indivisibles, the theory of which he possessed in 1629, although it was not published until 1635. In this work, lines were considered as made up of points, surfaces as composed of lines, and solids as formed of surfaces. Cavalieri was exceedingly careful to verify his method, comparing his results with those which had been established by the ancient geometrical mode of demonstration; and, assured by their agreement, he ventured boldly in his new career. His principles were attacked, but he defended them by showing that they might be translated into those of Archimedes, from which they only differed in brevity of expression; his surfaces and lines being in fact merely the thin solids and small inscribed and circumscribed triangles of the ancient geometer, and their number being supposed so great that the difference between them and the figure about which they were described was less than any assignable quantity.

The new views proposed by Kepler were taken up in France by Roberval, who had carefully studied the writings of Archimedes, and formed a theory by which he could resolve problems concerning curvilineal figures. Instead of supposing lines to be made up of points, and surfaces of lines, as had been assumed by Cavalieri, he regarded a line as composed of an infinite number of infinitely short lines, a surface as composed of an infinite number of infinitely narrow surfaces, and so on; an assumption which at bottom was the same as that of the Italian geometer, but capable of being wrought up into a theory differing less from the spirit of the ancient geometry. Roberval concealed his views, employing them secretly as the means of invention in geometry, and expecting in this way to get the start of his contemporaries in reputation as a geometer. In the meanwhile the work of Cavalieri appeared and frustrated his selfish expectations.

The facility which the introduction of the notion of infinitely small quantities gave in the extension of geometry, induced all the mathematicians of that day to employ it in their researches. In the doctrine of curve lines it was applied to the theory of tangents by Roberval, Descartes, and Fermat, with great success. So very near had this last-mentioned geometer approached to the fluxional or differential calculus, that Laplace says he ought to be reputed its true inventor. Laplace was no doubt a great authority; but the facts on which he formed his opinion have always been generally known, and no one before him has attempted to reverse the decision of the age in which the calculus was invented. The justice of the decision has been subjected to a scrutiny by men of the highest powers of mind, who, differing in many of their opinions, have yet agreed in ascribing the invention to others.

The problem of drawing tangents to curves is indeed closely connected with the calculus, and at the period when this was about to be revealed that problem was much agitated, and successfully resolved by Slusius, Wallis, Barrow, and others. The writings and discoveries of Descartes exerted a most beneficial influence on the new geometry, particularly by his happy application of algebra to geometry. Before his time geometrical problems had been resolved by algebra, and a rich mine of discovery thereby opened. But he was the first who thought of applying algebraic formulæ to express the nature of curve lines; an invention of vast importance to both branches of mathematical science.

Another most important benefit that resulted from the new views which Descartes brought forward, was the notion of *variable quantity*. The early analysts distinguished quantities chiefly from the circumstance of their being known or unknown; and the main object of inquiry with them was to discover the chain of reasoning by which they might pass from the given quantities to the determination of those required. The view which Descartes took of geometrical magnitude brought the *relations* of quantities forward as a principal subject of contemplation. A new subject of discussion was brought into mathematical science, namely, the changes which take place in quantities connected by an invariable relation, when one of them is supposed to change its value, and pass from one state of magnitude to another. The science of geometry owes its elegance and the variety of its doctrines to the combined effect of magnitude and position, as they influence the subjects under consideration; and, in addition to these, the doctrine of curve lines has introduced a new element, namely, the property of varying in magnitude, as an attribute of quantity. This property of indefinitude, in respect of greatness, although it may appear a trivial affection of quantity, has, however, led to the most important consequences; for from this, combined with other principles, have sprung the fluxional calculus and other mathematical theories, which, originating in the ordinary conceptions of the human mind, have engaged the attention of men endowed with the highest powers of intellect for more than a century past.

In the progress of time the notions of infinite quantity introduced by Kepler, Cavalieri, and others, into mathematics, became familiar to geometers, who perceived the immense value of the improvement, and saw that, by due care in its application, there was no risk of its leading into error. Dr Wallis, in the year 1655, gave an admirable specimen of this new analysis in his *Arithmetic of Infinites*; a work which contained the first traces of the algebraic analysis applied to the quadrature of curvilineal spaces. Pursuing the views of Cavalieri, he reduced the problem of finding the areas of curves to the summation of the powers of an arithmetical series, consisting of an infinite number of terms, or rather the ratio of the mean of all the terms to the last term. He also showed by the same principles, that certain curve lines might be *rectified*, or that straight lines might be found to which they were exactly equal; a remark that was shortly afterwards verified by William Neil, a young mathematician of that period, who, at the age of nineteen, showed that the length of the semicubical parabola might be found in finite terms. This was the first curve that was rectified, and the second was the cycloid, a discovery due to Sir Christopher Wren.

Thus the principles of the fluxional calculus were at this period coming gradually into view. Their importance was seen and understood, and in substance, although without an appropriate notation, they were employed in extending the dominion of geometry; it might therefore be supposed that in the course of time they would have been gradually formed into a system, just in the way the science of algebra advanced from the rude form it had when first introduced into Italy, to that degree of compactness and perfection which it acquired by the successive improvements of Vieta, Harriot, and Descartes. But, in the case of the fluxional calculus, a happy combination of circumstances anticipated the slow operation of time. Newton and Leibnitz, two men endowed with the highest powers of mind, appeared nearly at the same time in the field of discovery. The genius of each shone with resplendent lustre, even amidst the blaze of intellect which enlightened the latter period of the seventeenth century, and which has rendered it for ever memorable in the annals of hu-

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man knowledge. They both turned their attention to this branch of mathematical science, and, as is now generally admitted, each, independently of the other, collected the undigested principles into a system, and, by a powerful effort, performed at once what the united labour of ordinary minds would have hardly accomplished in a century.

In ascribing to each of these great men the full honour due to the merit of the invention of the calculus, it is proper to add, that this is a question which at one time divided the opinions of the learned world, and gave rise to a controversy which was agitated with great keenness for almost a whole century. There never could be any doubt as to Newton being the inventor of the calculus of fluxions. He has been acknowledged by all to have been the inventor, and the first inventor; but the question strongly contested has been, whether Leibnitz, without knowing what had been done by Newton, invented his differential calculus by the force of his own mind, or borrowed it from the fluxional calculus, with which at bottom it is identical.

In the course of this controversy it was clearly established by the British mathematicians, who almost to a man ranged themselves on the side of their illustrious countryman, that, as far back as the year 1669, Newton, then in his twenty-sixth year, and a fellow of Trinity College, communicated to Dr Barrow a tract, entitled *De Analysi per Æquationes Numero Terminorum Infinitas.* In this manuscript the method of fluxions was first indicated; and rules deduced from it given for the quadrature of curves, and various other matters to which the calculus is applicable, were distinctly specified. From this tract, which was sent by Dr Barrow to Collins, the secretary of the Royal Society, it is established beyond all doubt that Newton was then in full possession of his method; and indeed it is certain from other evidence that he must have had it as far back as 1666. The important discoveries made by Newton were communicated without reserve by the secretaries of the Royal Society to mathematicians on the Continent, as well as to those in Britain. In this way it might be generally known that Newton possessed a most valuable instrument of research, by which he had been led to these results, although its nature was too obscurely indicated to give any assistance in divining its precise form.

Leibnitz appears to have been later than Newton in beginning his career of discovery in the mathematics. In the year 1672, being then in London, he communicated to some members of the Royal Society what he supposed to be discoveries relating to the differences of numbers. It was, however, shown to him that the same subject had been discussed long before, by Mouton, a French geometer. He then appears for the first time to have turned his attention to infinite series. Afterwards, on his return to Germany in 1674, he announced to Mr Oldenburgh, then secretary of the Royal Society of London, that he possessed very general analytical methods, by which he had found theorems of great importance relating to the quadrature of the circle, by means of series. In answer, the secretary informed him that Newton and James Gregory had also discovered methods which gave the quadrature of curves, and which extended to the circle.

In the year 1676 Newton addressed a letter to the secretary of the Royal Society, which was made known to Leibnitz. This was the first direct communication between these two great men. It contained the binomial theorem, which Newton had known in the year 1669, and a variety of other matters relating to infinite series and quadratures; but nothing directly relating to the method of fluxions. At this time Newton entertained no jealousy of Leibnitz, for he speaks of him in the letter with great respect. In a second letter Newton explained at his request the way in which he had found the binomial theorem, and he adverted also to his own calculus, explaining the purposes to which it could be applied, but concealing its nature under the form of an anagram of transposed letters, which was expressed thus, *6accdae13eff713l9n4o49rr4s9t12vx.* It is not easy to see what certain information Leibnitz could draw from this assemblage of characters; yet such was the effect of national prejudice in biassing the minds of the British mathematicians, that Raphson, in his *History of Fluxions*, a work dedicated to the Royal Society of London, expressly asserts that Leibnitz deciphered the anagram, and found it to be this sentence, *Data equatione fluentes quotcunque quantitates involvente invenire fluxiones, et vice versa.* "Having any given equation involving never so many flowing quantities, to find the fluxions, and *vice versa.*" We believe there was not the least ground for this assertion; and from such a specimen of want of candour, it is easy to infer that there was very little chance of Leibnitz getting justice done him by the English mathematicians.

In the month of June 1677 Leibnitz sent to Mr Oldenburgh, to be communicated to Newton, a letter containing the first essays of a method which extended to all that could be done by that of Newton. The death of Oldenburgh, which happened soon afterwards, put an end to the correspondence, and it was not until the year 1684 that Leibnitz made his discovery public, it being then inserted in the Leipsic Acts; so that whilst Newton's claim to the priority of the discovery must be admitted by all, it is not less certain that Leibnitz was the first to give the full benefit of the calculus to the world; for Newton's Method of Fluxions only became generally known in the year 1687, by the publication of his *Philosophiæ Naturalis Principia.*

It is certain that Leibnitz enjoyed unchallenged for fifteen years the honour of being the inventor of his calculus; even Newton himself rendered him that justice in the first edition of his immortal work. Subsequently, however, a foreign mathematician, Fatio de Duillier, piqued, it is said, by having been omitted in an enumeration of eminent geometers by Leibnitz, declared, in a treatise on the line of shortest descent, printed at London in 1699, that he was obliged by the undeniable evidence of things to acknowledge Newton not only as the first, but as by many years the first inventor of this calculus; from whom, whether Leibnitz, the second inventor, borrowed any thing or not, he would rather they who had seen Newton's letters and other manuscripts should judge than himself.

The insinuation contained in this passage of Fatio's book could not but be very offensive to Leibnitz, who inserted an animated reply in the Leipsic Acts of 1700, and complained to the Royal Society of London of the injustice done him; and here the affair rested for a time: but it was revived some years afterwards. When Newton's treatise on the quadrature of curves, and his enumeration of lines of the third order, was published, the Leipsic journalists gave an unfavourable review of the work. Amongst other things, after a brief exposition of the nature of fluxions, they added, that Newton uses and has always used fluxions for the differences of Leibnitz, just as Fabri had substituted in his synopsis of geometry motion instead of the indivisibles of Cavalieri. This most unjust accusation excited great indignation in the minds of the British mathematicians, one of whom, Keill, Savilian professor of astronomy at Oxford, in a paper inserted in the *Philosophical Transactions* of the year 1708, affirmed that Newton was the first inventor of the calculus, and that Leibnitz, in publishing it in the Leipsic Acts, had merely changed the name and the notation. Leibnitz, thus directly charg-

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ed with having taken his calculus from that of Newton, addressed a letter to Mr, afterwards Sir Hans Sloane, the secretary of the Royal Society, in which he required that Keill should retract his accusation. Keill however refused to do this, and in answer addressed a letter to the secretary, in which he professed to show, not only that Newton had preceded Leibnitz in the invention, but that he had given so many indications of his calculus that its nature might easily be understood by any man of ordinary understanding. This letter was sent to Leibnitz, who addressed a second letter to the Royal Society, requiring that they should stop these reproaches of Keill, saying that he was too young a man to know what had passed between him and Newton.

The society, thus appealed to as a judge, appointed a committee to examine the old letters, papers, and documents which had passed between the mathematicians on the subject. The report of this committee does not appear altogether satisfactory. "We take the proper question to be," say the reporters, "not who invented this or that method, but who was the first inventor of the method; and we believe those who have reputed Leibnitz the first inventor, knew little or nothing of the correspondence between Mr Collins and Mr Oldenburg long before, nor of Mr Newton having that method about fifteen years before Mr Leibnitz began to publish his in the *Acta Eruditorum* of Leipsic; for which reason we reckon Mr Newton the first inventor, and are of opinion that Mr Keill, in asserting the same, has been nowise injurious to Mr Leibnitz." This declares nothing on the only point about which there could be any doubt, namely, whether Leibnitz had formed his calculus entirely by the power of his own genius, or had availed himself of a knowledge of Newton's invention. The judgment satisfied neither party. Keill wished to establish against Leibnitz the charge of plagiarism, but was disappointed; and Leibnitz found in the decision grounds of complaint against the Royal Society. In a communication to the Abbé Conti, a Venetian nobleman and a common friend of his and Newton, then in England, he accused the English nation of desiring to be considered as almost the only inventors. He said it did not appear, as had been well observed by Bernoulli, that Newton possessed before him the infinitesimal characteristic and algorithm, although it would have been easy to have found it if he had been so disposed, just as it would have been easy for Apollonius to have discovered the theory of curve lines of Descartes. He complained that his opponents had attacked his candour by forced and unfounded interpretations of his words. The question was the calculus of differences, and his opponents made it turn entirely upon series, where Newton had no difficulty in going before him. He maintained that he had found for himself a general method for series, and that he had no need of Newton's method of extractions. There were other grounds of complaint, such as, that only extracts from letters had been given in the *Commercium Epistolicum*, whereas the entire letters should have been published. Throughout the whole, which is a postscript to a letter, he manifests much chagrin; and he concludes with proposing this problem, intended, he says, to feel the pulse of the English analysts: To find a line which shall cut perpendicularly all curves of a determinate series, and of the same kind; for example, all hyperbolas, which shall have the same vertex and centre. This he desires the abbé to propose as from himself, or a friend.

In the abbé's reply to this letter he informed Leibnitz that he had delayed writing until he could at the same time send the answer which Newton had given to his postscript. He tells him that he had read the *Commercium Epistolicum*, and the originals of the letters which it contained, and, on the whole, he inferred that, setting aside matters foreign to the dispute, the only question at issue was, whether Newton had found the Calculus of Infinitesimals, or Fluxions, before, or after him? The abbé says, you published it first, it is true; but you admit that Newton allowed much to transpire in the letters which he wrote to Oldenburgh and others. This has been proved at length in the *Commercium* and its extract; what is your answer? This is what the public requires, to form a correct opinion on the matter. The abbé further informs Leibnitz that his friends believe he ought to give an answer, if not to Keill, at least to Newton himself, who, in the letter which the abbé had received from him to be communicated to Leibnitz, had challenged him in express terms. In a spirit of friendship and good sense, he further adds, that he wishes to see a good understanding between them, that the public will profit but little by their disputes, and that the additions to knowledge which they prevent are a pure loss to posterity. He moreover tells him that the king, George I., had desired to be informed of all that had passed between Newton and him. From this we may judge what an interest was excited in the public mind by a dispute which, even at this day, few could perfectly understand. The answer which Leibnitz gave to the abbé's friendly advice was, that he had put his letters, and Newton's, with his own answers to them, into the hands of Mr Remond at Paris, with a view to have a neutral and impartial opinion as to the matters in dispute. The whole were then to be submitted to the Abbé Varignon and other members of the Royal Academy of Sciences, and afterwards sent to England. In his answers he disavowed the sense which the English mathematicians had extracted from the assertion of the Leipsic journalists, namely, that Newton employed and always had employed fluxions for the differentials of Leibnitz, which they understood to mean that Newton had availed himself of Leibnitz's method, only substituting fluxions for differentials. It was from this passage that the English had declared Leibnitz to be the aggressor, in having abetted an attack of Newton; but Leibnitz declared the English interpretation to be full of malignity towards him, and that the sentence in the *Leipsic Acts* (*Pro differentiis Leibnitianis D. Newtonus adhibet semperque adhibuit fluxiones*), meant that Newton had employed fluxions after having seen his differences, and also before he had seen them.

We believe enough has been detailed to show that, besides a desire to arrive at truth, there was infused into this controversy the jealousy of two rivals for the glory of a great discovery; and, in addition, the spirit of partizanship of their respective admirers, and that natural feeling which induces men of different countries to exalt their own nation, although sometimes at the expense of their neighbours. It is not wonderful, then, that at the time this controversy was at its height, men were greatly divided in their opinions.

It is now impossible to obtain absolute certainty as to the question, whether Leibnitz derived any aid from the discoveries previously made by Newton, which, to a certain extent, were made known to the scientific world. It may therefore be some satisfaction, in the want of perfect evidence, to have the judgment of Montucla, the historian of the mathematics, on this subject. "In regard to the principle of fluxions," says he, "there are only three places of the *Commercium Epistolicum* which treat of it with sufficient clearness to prove that Newton had found it before Leibnitz, but I believe too obscurely to take from him the merit of the discovery. One of these is a letter from Newton to Oldenburgh, who had remarked to him that Slusius and Gregory had found a very simple method of tangents. Newton answered that he conjectured what it was, and he gave an example, which is in effect the same thing as these two geometers had found. He added that it was but a particular case, or rather a corollary to a method much more general, by which tangents to all sorts of curves, whether geometrical or mechanical, might be found without laborious calculation. He repeated the same thing, without explaining himself further, in his second letter, which has been already mentioned, and he concealed the principle under transposed letters. The only writing in which Newton had allowed any thing of his method to transpire is his *Analysis per Equationes numero Terminorum infinitas.* He there briefly and obscurely reveals his principle of fluxions. It cannot be denied that the principle and method were there indicated; but it is not certain that Leibnitz had ever seen the passage. His adversaries have never said that it had been communicated to him by letter; they have merely thrown out a suspicion that Collins might have communicated it to him in his second journey to London. Indeed the suspicion is not altogether void of probability, inasmuch as Leibnitz admitted that in his interview with the secretary he had seen a part of his epistolary correspondence. I believe, however, that it would be rash to pronounce upon this. There might have been grounds for suspicion if Leibnitz had merely given a few essays of his new calculus; but when we consider the improvements he made, as appears by the number of pieces he contributed to the *Leipsic Acts,* it seems probable that he owed his calculus to his own genius, and his efforts to divine the nature of a method by which Newton had made so many fine discoveries. This is the more probable, as from the method of tangents of Barrow to the differential calculus, the step is not too great to have been made by a power of mind of which Leibnitz had given so many proofs."

If it had been true, as the British mathematicians alleged, that Leibnitz had taken his calculus from that of Newton, it would have been a very remarkable circumstance that such a long period should have elapsed between his first putting forth his pretensions to the honour of the invention, and the denial of Newton and his friends. This is a thing uncommon in the history of contested claims to discovery, when both the claimants are alive and all the facts known. It is also remarkable that Newton, while in the prime of life, did not of his own accord bring forward a charge of plagiarism against his contemporary. On the contrary, in the first edition of his *Principia,* which appeared in 1687, he expressly admitted Leibnitz's claim; and this admission is found even in the edition of the *Principia* published in 1713. It is now well known, that before the period of the controversy between Newton and Leibnitz, the mind of the former had at one time been in a state which rendered him unfit to draw correct conclusions from the ordinary incidents of life; witness his letters to Mr Pepys and Mr Locke in September 1693 (Brewster's *Life of Newton*). At this time he seems to have laboured under great bodily indisposition, from which he afterwards in appearance recovered; indeed it may be doubted whether his temper was so equal and mild in the latter period of his life as has been represented by his biographers. A collection of letters which passed between Flamsteed the astronomer and Abraham Sharp the celebrated calculator, which have lately come into the possession of the Astronomical Society of London, prove that Newton, in conjunction with Halley, opposed Flamsteed in the publication of his *Historia Cœlestis,* a work of the highest merit, and the result of the labour of his life, with a pertinacity of purpose which is by no means an amiable trait in his character. It is certain that Newton entertained towards Leibnitz a very different feeling at one period of his life, from that which he in the end evinced. In the edition of the *Principia* 1713, and those which preceded it, he says, "Ten years ago, in a correspondence with Mr Leibnitz, I informed him that I had a method of determining maxima and minima, of drawing tangents, and resolving similar problems, which applied alike to rational and irrational terms, but concealed it under transposed letters. He answered that he had found a like method, which he communicated, and which differed from mine only in the terms and the signs, and in the way of conceiving quantities to be generated." This concession was liberal, and worthy of Newton. However, in the edition of 1726, he retracted this act of justice, having struck out the passage, as Montucla assures us, with his own hand. The historian of the mathematics, however, finds an excuse for this harshness in the treatment which Newton had received from Leibnitz's friends.

The circumstance of the calculus having had two distinct origins, had the inconvenient effect of giving it two different forms and names. Newton at different times used different notations before he finally adopted that which has been followed by the English mathematicians. Leibnitz and his followers employed one somewhat different; and each sect pertinaciously adhered to the example set by its leader. There was a still greater difference in the view which each party took of quantity, and the way in which it may be generated. Newton conceived geometrical magnitudes to be generated by continued motion, a line by a point in motion, a surface by a moving line, a solid by a moving surface, an angle by a line turning about a point, and so on. It is evident, that by assuming geometrical quantities as the representatives of time, force, and whatever can be expressed by number, these can be conceived to increase or decrease according to the same laws as their geometrical representatives. His calculus therefore consisted of two parts:

1*st,* Supposing two quantities to have a given relation to each other (for example, the one to be always equal to the square of the other), and the rate of increase of one of them at any instant of time to be known; to find the rate of increase of the other at the same instant. These rates of increase were called the *fluxions* of the quantities; and the rules for their determination constituted the *direct method of fluxions.*

2*d,* The second part was the reverse problem, in which the relation between the rates of increase of two quantities which depended the one on the other, being given, it was required to discover the relation of the quantities. This was the inverse method.

Leibnitz at first supposed quantity to increase by the addition of some indefinite portion of a quantity of the same kind, and his *differentials* were quantities proportional to the instantaneous changes in the greatness of the quantities thus generated. He afterwards found it shorter to introduce directly these instantaneous changes into his calculus under the name of infinitely little differences (*infiniment petites*). These however he did not regard as absolute *zeros,* but only as not comparable to finite magnitudes. His calculus had, like Newton's, two parts, the *differential calculus,* which gave rules for deducting the relation of the differentials of quantities from that of the quantities themselves, and the *integral calculus,* which resolved the reverse problem, or discovered the relation of the quantities when the relation of their differentials was known. This corresponded to the inverse method of fluxions, as the differential calculus corresponded to the direct method.

There is this distinction, then, between the two methods:

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Newton's fluxions are any finite quantities which have to each other the ratio of the velocities, or degree of quickness with which the quantities are generated. The differentials of Leibnitz are infinitely small quantities, a creation of the mind more removed from ordinary apprehension than the finite representatives of fluxions. This distinction has often been urged in favour of the superiority of Newton's calculus. On the other hand, Newton has introduced time into his calculus. Now this is an element foreign to geometry, and belonging to mechanics, a quite distinct branch of science. The metaphysical distinctions between the two forms of the calculus have had but little influence on its progress. Whichever of the two forms is chosen, the rules are the same; and so also are the difficulties to be overcome.

Some time elapsed before the newly invented calculus was actively employed. At length Leibnitz, to rouse the attention of geometers, proposed in 1687 this problem: To determine the curve along which a heavy body must descend, so as to approach by equal distances in equal times to a horizontal plane. Huygens was the first to resolve the problem. He showed what was the nature of the curve; but he did not give his demonstration. James Bernoulli also resolved the problem by the differential calculus, and published his analysis in the *Leipsic Acts*. His younger brother John united himself in a close friendship with Leibnitz, and continued throughout life his coadjutor and staunch defender. He made the calculus known in France, where he resided for a time, and gave lessons to the Marquis de l'Hôpital. Part of these form the *Analyse des infiniment Petits*, a work which bears the name of the marquis, with but a slight acknowledgment in the preface of the share which his preceptor had in its composition. Indeed it was almost entirely his; and of this injury Bernoulli complained justly, but privately, in his correspondence with Leibnitz. The remaining lessons, which teach the integral calculus, are given in the collection of Bernoulli's works, published in 1742. The whole form an excellent exposition of the principles of the calculus, and contain some of its finest applications.

The continental mathematicians who were remarkable for their skill in the differential calculus were at first few in number. They might be nearly all included in the names of Leibnitz himself, James and John Bernoulli, De l'Hôpital, and Varignon. They were, however, remarkably active, particularly the Bernoullis, whose writings have contributed powerfully to its advancement.

The inventor of the fluxional calculus seems to have taken but little interest in its extension. His treatise on quadratures did not appear till 1706; and his work on fluxions was not published in his life time, but appeared in 1736, nine years after his death. He had however fully availed himself of its power in the composition of his *Principia*, without revealing to the full extent the nature of the instrument with which he wrought, but establishing the truth of his propositions by synthetic demonstration, after the manner of the ancient geometers. Probably this was done in deference to the taste of that time; for a contemporary writer, Hermann, in following his example in the composition of his *Phoronomia*, assigned to Leibnitz as a reason, that the geometrical method was likely to be better understood than the analytical in Italy. This way of proceeding is now, however, disused by the best writers, and replaced by the more legitimate and undisguised use of the calculus.

The extensive views which the new calculus opened up, afforded the means of resolving problems which had baffled the skill of the earlier mathematicians, and suggested many new ones, which without its aid would have been quite intractable. The cycloid and the catenary, curves which had eluded the penetrating mind of Galileo, were more fully comprehended; many new ones were suggested, and the cultivators of the calculus challenged each other to an investigation of their properties. There is an elegant class of problems which relate to the greatest and least values of quantities. Some of these, called problems of *maxima* and *minima*, can be resolved by the ordinary geometry and algebra; but there is a class which lies beyond the dominion of these, and to it belongs the solid of least resistance, the curve of swiftest descent, and, in general, the problems called *isoperimetrical*, one of the simplest of which is to find the nature of the line which, being given in length, shall comprehend the greatest possible space. These formed the subject of a warm but honourable contest between the two Bernoullis, brothers; and their investigation laid the foundations of that branch of the calculus, the highest, which has been formed into a theory by the labours of Euler and Lagrange, under the name of the *Calculus of Variations*.

Among the early cultivators of the calculus in Britain we may reckon Cotes, the friend of Newton, who died at the early age of thirty-four (his *Harmonia Mensurarum*, and other writings, indicate a genius of the highest order), De Moivre, Taylor, Craig, David Gregory, and Stirling. It must, however, be confessed, that the continental school in the course of time advanced before that of Britain, as well in the number of its disciples, as in their high mathematical genius and the importance of their discoveries. John Bernoulli had two sons, Nicolas and Daniel, who rivalled their father's skill in the applications of the calculus; and these had as condisciples Hermann and Euler. This last mathematician has carried the subject to a point of perfection far beyond what it had attained in the hands of those that had gone before him.

Amongst the means by which the improvement of the calculus has been promoted, we may reckon the problems which passed between the British and continental mathematicians as challenges to each other, in answering which Newton himself condescended sometimes to enter the lists. The doctrine of infinite series, a branch of the mathematics of English origin, gives powerful aid to the calculus in its greatest difficulties; but, legitimately, its assistance ought not to be called in if the problem admit of being resolved in finite terms. The English sometimes failed in the observance of this most proper condition of a good solution, and thus gave rise to reproaches from their opponents, which in at least one instance were not unjustly incurred by Newton himself. In the course of this warfare, Keill, the champion of the English, proposed as a challenge to John Bernoulli, to determine the nature of the curve which a projectile describes in a medium resisting as the square of the velocity. Bernoulli soon resolved the problem, not only in the case proposed, but also when the resistance was as any power whatever of the velocity. He then proposed to put his solution into the hands of some confidential person in London, provided that Keill would deliver his solution to the same person. Keill, however, had upon trial not been able to resolve the problem, and therefore preserved a profound silence, and made himself, by his boasting and failure, quite ridiculous. The triumph of Bernoulli was complete, and he did not miss the opportunity of bestowing severe castigation on his humbled adversary, recollecting, we may suppose, the treatment which his deceased and lamented friend Leibnitz had received from him and his friends.

As another proof of the spirit and rivalry of the supporters of the two analytical theories, we may mention that Brooke Taylor proposed a problem in the integral calculus to all geometers not English, and sent it to Mr Montmort to be communicated to the foreign geometers.

Introduction.

Notwithstanding the general terms of the challenge, it was well understood to be particularly aimed at John Bernoulli, who in return offered to wager fifty Louis that he would resolve the problem, and to stake fifty more that he would propose a problem which he himself could resolve, but which Taylor could not. The English mathematician did not think it prudent to accept the offered condition. Indeed it was a complaint against the English geometers, that although they made no scruple of trying to puzzle foreigners with difficulties, they rarely responded to the counter challenges proposed to themselves.

Perhaps there never was a considerable invention or discovery which had not to encounter opposition; sometimes from the slowness with which the human mind yields to the force of truth when opposed to long-received opinions, and sometimes from less excusable causes, such as mistaken or interested views, or mere jealousy excited by the fame of the inventor. The new calculus had in the very outset its opponents, such as the Abbé de Catelan, a zealous Cartesian, who declared that it would be better to extend the principles of the Cartesian geometry than to seek for new methods; and this was said in the preface of a book composed on the principles, somewhat disguised, of the very calculus of which he was an opponent. It had another adversary in Nieuwentiit, a man who had written some tolerable works on morality and religion, but who had but small pretensions to be regarded as a geometer. Catelan was satisfactorily answered by De l'Hôpital, as was Nieuwentiit by Leibnitz, and afterwards by Bernoulli and Hermann, who proved that this adversary of the calculus really did not know what he opposed.

The calculus had a more formidable enemy in M. Rolle, a skilful algebraist and indefatigable calculator, but a man full of confidence in his own notions, rash in forming his opinions, and jealous of the inventions of others. He attacked the certainty of its principles, and he attempted to show that its conclusions were at variance with those obtained by methods previously known, which were acknowledged to be correct. His attack was repelled by Varignon, who completely obviated the objections to the truth of the principles, and further showed that the supposed discrepancy between its conclusions and those obtained by other methods, were mistakes he had committed from haste and inadvertence. These disputes occupied the French Academy a considerable part of the year 1701. The members were chiefly geometers considerably advanced in years, who had been long accustomed to other methods, and were therefore not much disposed to receive new doctrines. Some took no part in the dispute, yet were not sorry to see a storm raised against a theory for which they had no great liking, and took no means to allay it; others, more under the influence of their passions and prejudices, yielded to these, and declared open war against it. In this state of things the best course was supposed to be that of hearing all which could be said for and against the calculus. The academy was long involved in the dispute. Rolle brought forward objection upon objection; and although Varignon continually obviated them, yet the former always claimed the victory. In the end the dispute degenerated into a real quarrel, and commissioners were appointed to decide on it. These were Père Gouye, MM. Cassini and de la Hire, who, however, pronounced no judgment; but the public opinion, or at least the opinion of geometers, was in favour of Varignon. The first controversy thus ended, or at least was suspended, for want of a decision from the commission; but Rolle, the champion of the opponent of the calculus, soon renewed hostilities. Its defence was next taken up by M. Saurin. The ground of attack was the indefinite form which the calculus gives for the subtangent of a curve at the point where two branches intersect each other, and which in this case is expressed by the fraction $\frac{0}{0}$. Saurin's answer was satisfactory; but Rolle, intrenched in masses of calculation, obstinately maintained the combat. The academy was again appealed to. The Abbé Bignon, who conducted its affairs, undertook to decide the controversy, with the assistance of MM. Gallois and De la Hire, two judges by no means favourable to Saurin. They gave no absolute judgment; but recommended to Rolle to conform more strictly to the rules of the academy, and to Saurin to forgive the proceedings of his adversary. Rolle suffered in the estimation of competent judges; he, however, afterwards did justice to the calculus, by acknowledging that he had done wrong in opposing it, and admitting that he had been urged forward by the instigation of malevolent persons, one of whom was the Abbé Gallois; and his demise in 1707 accordingly put an end to the controversy.

In England the Newtonian calculus had to sustain an attack on its principles from a writer of first-rate talents, Berkeley, bishop of Cloyne. The circumstances which led to it are curious. Mr Addison had given the bishop an account of the behaviour of their common friend, Dr Garth, in his last illness, which was highly unpleasing to these two advocates of revealed religion; for when Addison began to discourse with Garth on a future state, "Surely," said the latter, "I have no reason to believe these trifles, when my friend Dr Halley, who has dealt so much in demonstration, has assured me that the doctrines of Christianity are incomprehensible, and religion itself an imposture." The bishop therefore took up arms against Halley, and in the year 1734 addressed to him, as an infidel, a discourse called The Analyst, the object of which was to prove that mathematicians acted inconsistently in objecting to mysteries in faith, seeing that they did not hesitate to admit much greater mysteries, and even falsehoods, in their own science; and he chose the principles of the doctrine of Fluxions, as laid down by Newton and adopted by his followers, to prove the truth of his proposition. It may be supposed that so able a writer would not fail to make an impression on the public mind. But the mathematicians were not slow in coming forward in defence of the doctrines of their chief. In the same year came out a tract with this title: "Geometry No Friend to Infidelity, or a Defence of Sir I. Newton and the British Mathematicians, by Philalethes Cantabrigiensis," supposed to be Dr Jurin. As usual the attack was renewed, and again repelled by the same hand. Other defences of Newton appeared, one of the best of which was from the pen of Benjamin Robins; it was entitled A Discourse concerning the Nature and Certainty of Sir Isaac Newton's Method of Fluxions, and of Prime and Ultimate Ratios. But the most important result of this controversy was A Treatise on Fluxions from the pen of Colin Maclaurin, professor of mathematics in the university of Edinburgh, printed in 1742. This defence of the principles of Newton's views, expressly intended to obviate all objections, is quite satisfactory. The treatise is indeed considerably prolix; but this was a consequence of the circumstances in which it was composed. It however contains a great deal more than a mere theory of fluxions. We have in it some of the finest applications of analysis to the principal problems which had been agitated amongst geometers from the invention of the calculus to the time in which the work appeared.

By the middle of the century the calculus proceeded with a rapid march of improvement. Euler in 1744 greatly enriched it by his solution of the Isoperimetric Problem (*Solutio problematis isoperimetrici latissimo sensu accepti*), a theory which he afterwards wrought up into the Calculus of Variations, and which has been still further improved by Lagrange. Brooke Taylor, by his *Methodus Incrementorum*, had extended the foundations, and even proceeded a great way in the structure, of a kindred calculus, that of finite differences. Stirling had followed in the same path in his *Methodus Differentialis;* and Euler had opened a new field for discovery in the calculus of partial differences, in which D'Alembert followed his steps, and carried the subject further. The same period abounded in good writers. In this country Demoivre, Simpson, Landen, and Waring, stand among the foremost in the list for the originality of their views; on the continent Ricatti, Clairaut, Fontaine, and others, followed in the train of Euler and the Bernoullis.

It is a curious fact in the history of mathematics, that there are instances of ladies who have applied their talents to its study and improvement with much success. Hypatia, the daughter of the ancient geometer Theon, is one notable instance. Unfortunately we have no vestiges of her writings by which we might form an estimate of her proficiency in a science which at first sight seems not to have many attractions for the female mind. We have another instance in an Italian lady, Maria Gaetana Agnesi, who was actually professor of mathematics in the University of Bologna in the year 1748; and how well she was qualified for the office appears from her Analytical Institutions, a work of great excellence on algebra, the theory of curve lines, and the differential calculus, composed for the instruction of the youth of Italy. This work is so excellent, that Bossut, a French mathematician of great eminence, translated the part on the differential calculus into French, and incorporated it with his Course of Mathematics, as the best treatise he could find on the subject. There is also an English translation by the Rev. John Colson, Lucasian professor of mathematics in the university of Cambridge. Her countryman Frisi, a most competent judge, mentions her in enumerating the mathematicians of Italy, and bestows great praise on her work, calling it *opus nitidissimum, ingeniosissimum, et maximum certe opus quod hactenus ex feminæ alicujus calamo prodierit.* At the present time we have another admirable instance of a lady who has surmounted the difficulties of the calculus. Mrs Somerville, in her work entitled *Mechanism of the Heavens*, London, 1831, has enriched English literature with a treatise on physical astronomy, in which the different branches of the calculus are combined with the most refined theories of mechanics. Her book does her infinite credit, and indeed is highly honourable to the whole female sex.

Geometers have differed in opinion as to the best way of working up the principles of the calculus into a system. Newton, as has already been stated, employed the theory of motion as the means of connecting its doctrines with the principles of the ordinary algebraic analysis. Leibnitz, again, with the same view, conceived quantity as passing from one degree of magnitude to another by the continual accretion of infinitely small parts. The mind finds no great difficulty in distinctly apprehending the subject in its simplest state either way. Objections have, however, been taken to both, and attempts made to substitute a better. Euler considered the infinitely small quantities of Leibnitz as absolute zeros, that have to each other ratios derived from those of the vanishing quantities which they replace. D'Alembert proposed to make the basis of the calculus the consideration of the ratios of the limits of the quantities. An English mathematician, Landen, has substituted for the Newtonian method of fluxions another purely analytical. His views are contained in a work entitled The Residual Analysis, a new branch of the Algebraic Art, by John Landen, 1764. Lastly, Lagrange, in the Memoirs of the Berlin Academy for 1772, proposed to make the calculus altogether independent of the consideration of infinity, and to rest on principles purely analytical, thus connecting it with the doctrines of the ordinary algebra. He has since realised and extended his views in his *Théorie des Fonctions Analytiques*, also in his *Leçons sur les Calcul des Fonctions;* works which, from their excellence and the celebrity of their author, have formed a new era in the history of the calculus.

The twofold origin of the calculus, besides placing its principles on different foundations, gave it also two different forms of notation; and in this state it continued during the whole of the eighteenth century, to the great inconvenience of mathematical students, and, we may add, to the hindrance of the progress of science. A change, however, has taken place within the last twenty years; during that period some British geometers, imbued with the mathematics of the continent, adopted also its notation in preference to that of the followers of Newton, and employed it publicly in their researches. This spirit of innovation in time took possession of the minds of the junior members of the university of Cambridge, and now we may say that it has completely supplanted the native notation. We have retained the name of Fluxions, because, from the changes which have taken place in the way of treating the subject since the days of Leibnitz and Newton, it seems to be as proper as the term differential. It is otherwise with the notation. This is consecrated by its having been employed in the writings of Euler, D'Alembert, Lagrange, and other great masters in mathematical science; and besides, it has advantages over the other in point of symmetry and compactness, and the established reputation of a whole century of useful service. It is true, the late illustrious Lagrange laid it aside in his attempt above mentioned to new-model the calculus; but subsequent writers, in extracting what was excellent from his works, have in general invested his views with the ordinary notation of the continent. In the following treatise we shall conform to this beneficial alteration.

Writers on the Infinitesimal Calculus, before the Invention of the Method of Fluxions.

Kepler, Nova Stereometria Doliorum Vinariorum	1615
Cavalieri, Geometria Indivisibilium	1635
——— Exercitationes Geometricæ Sex	1647
Roberval, Traité des Indivisibles. Mém. de l'Acad. des Sciences	1666
Descartes, in his Letters and Geometry, book 2d, and his mathematical works	1637
Torricelli, De Sphæra, et Solidis Sphæralibus	1644
Gregory St Vincent, Opus Geometricum de Quadratura Circuli	1647
Wallis, Arithmetica Infinitorum	1655
Fermat, Opera Varia Mathematica	1679
Mercator, Logarithmo-Technia	1668
James Gregory, Vera Circuli et Hyperbolæ Quadratura	1668
Brouncker, Squaring the Hyperbola, *Phil. Trans.* London	1668
Huygens, Opera; Horologium Oscillatorium	1673, 1724
Barrow, Lectiones Geometricæ	1670
Slusius, Tangents to all Geometrical Curves, *Phil. Trans*	1672
Wren, Rectification of the Cycloid, *ibid*	1673
Ismael Bullialdus, Arithmetica Infinitorum, libri. vi	1682
Leibnitz, Quadrature of the Circle, *Leips. Acts* and *Phil. Trans.*	1682
Viviani, Exerc. Math. de Formatione et Mensura Fornicum	1692

Writers on the Fluxionary or Differential Calculus.

Newton, De Analysi per Æquationes numero terminorum Infinitas, circulated in manuscript in 1669, and printed in the *Commercium Epistolicum*, 1712. Also contained in a volume edited by W. Jones, and entitled Analysis per Quantitatum Series, Fluxiones, ac Differentias	1723
——— Principia, lib. ii. sect. iii. lemma 2	1687
——— Tractatus de Quadratura Curvarum, published with his Optics	1704
——— The Method of Fluxions	1736
Leibnitz, Nova Methodus pro maximis et minimis itemque tangentibus. *Leipsic Acts*	1684
James Bernoulli, Analysis Magni Problematis Isoperimetrici; *Acta Erud.* See also his Works	1744
John Bernoulli, *Acta Erud. Leip.*; also *Mémoires de l'Acad. des Sciences*	1742
Leibnitz and Bernoulli, Commercium Phil. et Math. 2 vols. 4to	1745
Demoivre, Use of Fluxions in Geometric Problems, in the *Phil. Trans.*	1695
De l'Hôpital, Analyse des Infiniment Petits	1696
David Gregory, On the Catenary, *Phil. Trans.*	1697
Carré, Méthode pour la Mésure des Surfaces	1700
Craig, Solid of least Resistance and Curve of quickest Descent, *Phil. Trans.*	1700
—— De Calculo Fluentium	1718
Cheyne, Fluxionum Methodus Inversa	1703
Harris, Lexicum Technicum	1704
Hayes, A Treatise on Fluxions	1704
Ditton, Institution of Fluxions	1706
Manfredi, De Construct. Equat. Diff. primi gradus	1707
Taylor, Methodus Incrementorum	1715
Cotes, Harmonia Mensurarum	1722
—— Estimatio errorum in mixta Mathesi	
Riccati, Animad. in Equat. differentiales, secundi gradus, *Acta Erud*	1724
Clarke, An Institution of Fluxions	1726
Hermann, De Constructione Equationum Differentialium, *Comm. Petrop*	1726
Fontenelle, Eléméns de la Géométrie de l'Infini	1727
Clairaut, Determinatio Curvæ ejusdem Differentialis, *Acta Erud*	1729
Demoivre, Miscellanea Analytica	1730
Stone, Method of Fluxions	1730
Hodgson, The Doctrine of Fluxions	1736
Deidier, Le Calcul Différentiel	1740
Simpson, A Treatise on Fluxions	1737 and 1750
Maclaurin, A Treatise on Fluxions	1742
Emerson, The Doctrine of Fluxions	1743
Donna Agnesi, Instituzioni Analitiche	1748
French translation of the same work by Cousin	1775
An English translation by Colson	1801
Euler, Methodus Inveniendi Lineas Curvas maximi minimive proprietate gaudentes	1744
—— Introductio in Analysin Infinitorum	1748
—— Institutiones Calculi Differentialis	1755
—— Institutiones Calculi Integralis	1768–70
The titles of Euler's academical memoirs, of which there is a very great number on the Differential Calculus, are given in the edition of his *Calculus Differentialis*, printed at Pavia in 1787, and occupy thirty-two quarto pages.	
Walmesly, Analyse des Mésures des Rapport et des Angles	1750
Stirling, Methodus Differentialis	1753
Bougainville, Traité du Calcul Intégral	1754
Landen, Mathematical Lucubrations	1755
——— The Residual Analysis	1764
Landen, Mathematical Memoirs	1780
Saunderson, Method of Fluxions	1756
Lyons, Treatise of Fluxions	1758
Kaestner, Separatio Indeterminat. in Æquat. Diff.	1756
D'Alembert, Opuscules Mathématiques	1761–80
Robins, Mathematical Tracts	1761
Waring, Miscellanea Analytica	1762
——— Meditationes Analyticæ	1776
Condorcet, Du Calcul Intégral	1765
Le Seur et Jacquier, Elémens du Calcul Intégral	1768
Lexell, Methodus Integrandi Æq. Diff. *Comm. Petrop.*	1769
Fontaine, Traité du Calcul Diff. et Intégral	1770
Gianella, De Fluxionibus et earum Usu	1771
Cousin, Leçons du Calcul Différentiel, &c	1777
La Place, l'Usage du Calcul aux Différences partielles, *Mém. de l'Acad.*	1777
Condorcet, De Integ. cujusdam Æquationis, *Comm. de Bonon.*	1783
Malfatti, Delle formale differentiali la cui integrazione dipende dalla rettificatione delle sezione coniche	1784
Paoli, Memoria sull' equazione a differenze finite e parziali	1784
Monge, Sur le Calcul Intégral des Equat. aux Dif. partielles, *Mem. de l'Acad*	1784
Charles, Recherches sur le Calcul Intégral, *Mem. de l'Acad.*	1784
L'Huillier, Exposition des Principes de Calcul Supérieur	1786
——— Principiorum Calculi Diff. et Integ	1795
Mascheroni, Annotationes ad Cal. Integ. Euleri	1790
Tabiescen, Principia atque Historia Calculi Differ. et Integ. nec non Methodi Fluxionum	1793
Lagrange, Calcul des Variations, *Mis. Taur.* vol. ii. and iv.	1760–69
——— Théorie des Fonctions Analytiques	1797
2d edit	1813
——— Leçons sur le Calcul des Fonctions, 2d edit	1806
The titles of his Memoirs, inserted in Academical Collections, are given in his Mécanique Analytique, second edition	1795
Vince, Principles of Fluxions	1797
Carnot, Réfléxions sur la Métaphysique du Calcul Infinitesimal	1797
Bossut Traité du Calcul Différentiel	1798
Lacroix, Traité du Calcul Différentiel et du Calcul Intégral, first edit. 1797, second	1810–19
Abrogast, Du Calcul des Dérivations	1800

The preceding catalogue contains the names of the principal improvers and cultivators of the calculus, from its first invention to the end of the last century. However, it does not contain all their writings; to have enumerated these would have extended the catalogue to too great a length. Almost all the improvements of the calculus were first given in the form of academical memoirs, from which they have been drawn, and incorporated into the systems that have from time to time been published. The great repertories in which it is contained are the writings of Newton, Cotes, Demoivre, the Bernoullis, Maclaurin, Simpson, Euler, D'Alembert, Lagrange, Legendre, La Place, Monge, Poisson, Gauss, Ampère, Ivory, &c. From these have been constructed the treatises of De l'Hôpital, Bougainville, Le Seur and Jacquier, Cousin, and others, which were the most complete at the different periods when they appeared. At this time the most extensive treatise is the second edition of Lacroix, which came out between 1810 and 1819. In the present century there have been published in France treatises by Garnier, Du Bourguet, Boucharlat, Cauchy, and others which we have not seen. In Britain we have had treatises by Woodhouse, Dealtry, Lardner, Jephson, Young, Thomson, and others. The university of Cambridge, long infertile, now teems with treatises on the subject, such as those of Brown, Coddington, Earnshaw, Hymer, Jarret, Millar, Myers, and Peacock. There are, besides, treatises on the calculus in courses of mathematics, such as the Elementi d'Algebra of Paoli, the Cours des Mathematiques of Bezout, a like work by Francœur, &c. There have also been works constructed for the benefit of students, which may be used with any treatise on the subject, such as the excellent collection of examples by Peacock, Herschel, and Babbage, which was intended as an accompaniment to an English translation of an abridgment of Lacroix's treatise; and the integral tables of Hirsch, which have been translated from the original German into English.

There is a branch of the calculus of great interest, which of late has engaged, and will probably long engage, the attention of mathematicians; we mean the subject of *Elliptic Transcendents.* This theory originated in the discovery of a very remarkable property of the ellipse and hyperbola by Fagnano, an Italian mathematician, who first showed that arcs of these curves can be assigned, of which the difference is expressible in finite algebraic terms. This most interesting subject has been discussed by the following writers:

Fagnano, Produzioni Mathematiche, tom. ii. p. 336...1750
Euler, Calculus Integralis, tom. i. sect. ii. and tom. iii. supp.
Bossut, Leipsic Acts, 1754; Mém. de Math. et de Phys. tom. iii.
Landen, Lond. Phil. Trans. 1775; and Mathematical Lucubrations..........1780
Legendre, Mém. de l'Acad. des Sciences, 1786; Mémoire sur les Transcendantes Elliptiques, 1792. (There is an English translation of this memoir in Leyburn's Mathematical Repository, vols. ii. and iii. new series.) Exercices de Calcul Intégral, 3 vols.; Schumacher's Journal, Nos. 123, 127, 130.
——— Traité des Fonctions Elliptiques............1825
——— Miscell. Taur. tom. iv.; Théorie des Fonct. Analytiques, 2d edit.
Ivory, New Series for the Rectification of the Ellipse, Trans. R. S. Edin. vol. iv.; Fagnani's Theorem made more general, Leyburn's Math. Repository, vol. i. new series; On the Theory of the Elliptic Transcendents, Trans. R. S. Lond. 1831.
Wallace, Formula for the Rectification of an Ellipse, &c., Trans. R. S. Edin. vol. v.
Woodhouse, Integration of Certain Differentials, Trans. R. S. Lond. 1804.
Brinkley, Demonstration of Fagnani's Theorem, Trans. Irish Acad. vol. ix.
Abel, J. Crell's Journal, vol. ii.
Jacobi Fundamenta Novæ Theoriæ Functionum Ellipticarum..........1829
Plana, Memoir read in the Turin Academy..........1828

PART I.

DIRECT METHOD OF FLUXIONS, OR DIFFERENTIAL CALCULUS.

1. In the application of algebra to the theory of curve lines, some of the quantities under consideration are conceived as having always the same magnitude as the parameter of a parabola, and the axes of an ellipse or hyperbola; others again are indefinite in respect of magnitude, and may have any number of particular values; such are the co-ordinates at any point in a curve. This difference in the nature of the quantities has equally place in various theories of the pure and mixed mathematics, and it naturally suggests the division of all quantities into two kinds; namely, such as are constant, and such as are variable.

A constant quantity is that which is supposed to have always the same value. A variable quantity, again, is that which may change its value by increasing or decreasing, so that in passing from one degree of magnitude to another it will have had in succession every possible intermediate magnitude.

Thus, in a circle, the radius is a constant quantity, and any arc of the circle, also its cosine, sine, tangent, secant, &c. are variable quantities. In the ellipse, the axes or semiaxes are considered as constant; and the co-ordinates to any point in the curve, and in general any lines or spaces or angles which in the same ellipse admit of different values, are variable. So again in the parabola, the parameter is constant, and the co-ordinates to any point in the curve, also any arc of the curve, and the space contained by that arc and the co-ordinates, are to be regarded as variable.

In what follows, we shall in general call constant quantities simply *constants,* and variable quantities *variables.*

It is usual to denote constants by the letters $a, b, c,$ &c. towards the beginning of the alphabet, and variables by the letters $x, y, z,$ &c. towards the end.

2. One quantity is said to be a *function* of another when they are so related that the latter being supposed to change its value, the former also changes its value. Thus, in geometry, the radius of a circle being constant, the cosine, the sine, the tangent, the secant, &c. are functions of the arc. On the other hand, the arc may be considered as a function of any one of these quantities. In mechanics, the force by which a body is urged forward, the space it has passed over, and its velocity at every instant, may all be regarded as functions of the time.

In this algebraic expression,

$$y = \frac{a+x}{a-x},$$

in which a is a constant and x a variable, the quantity y is regarded as a function of x, which is called the *independent* variable. Here y is expressed by x; but by resolving the equation, x may be expressed by y thus:

$$x = \frac{a(y-1)}{y+1};$$

the quantity x is now a function of y. In either case, the constants a and 1 are not considered. In these examples,

$$u = a + bx + cx^2,$$
$$u = \sqrt{(a^2 + bx + x^2)},$$
$$u = \frac{a + \sqrt{bx}}{c + x^2},$$

u is a function of x.

A quantity may be a function of several independent variable quantities. Thus, in the expression

$$u = ax^2 + bxy + cy^2,$$

u is a function of the independent variables x and y.

The variety of forms of functions of a variable is endless. They may, however, be resolved into a few elementary functions such as these,

$$x^n, \quad a^x, \quad \log x, \quad \sin x, \quad \cos x.$$

The first of these, x^n, in which n is constant, and all that can be formed from it by a finite number of the elementary operations of algebra, are called *algebraic* functions; for example, this,

$$u = ax^3 + \frac{bx^2 - c^2x}{\sqrt{a^2 + x^2}},$$

which is formed by addition, subtraction, multiplication, division, and the extraction of the square root. These two, a^x, $\log x$, which cannot be expressed by a finite number of terms composed of powers of x, are called *transcendental* functions, and the remaining two, $\sin x$, $\cos x$, and such as may be formed from them, viz. $\tan x$, $\sec x$, &c. are called *trigonometrical*, also *angular* and *circular* functions.

In the last example, the value of the function u may be immediately found, if the value of x be known. Such functions are called *explicit*. There are functions, however, which require to be separated from the variable by the resolution of equations, or other means, before their value can be found; as in this example,

$$ux = \frac{u + x}{u - x},$$

in which u is supposed to be a function of x. In this case, before the value of u, corresponding to a given value of x, can be found, a quadratic equation must be resolved. Such a function is called an *implicit* function of x. On the other hand, x is an implicit function of u. By the resolution of an equation we find

$$u = \frac{1}{2}\left\{x + \frac{1}{x} + \frac{\sqrt{x^4 + 6x^2 + 1}}{x}\right\};$$

u is now an explicit function of x.

The early algebraists indicated the square root of a quantity by placing the letter r before it; thus rx meant the square root of x. The letter was afterwards changed into the sign $\surd$, and the square root of x was conveniently expressed thus, $\sqrt{x}$. In like manner, it is convenient to have a symbol which shall express generally a function of a variable, and accordingly it is now usual to express any function of a variable x by the symbol fx or $f(x)$; also by $\mathrm{F}x$, or φx. Here the letters f, or F, or φ, are considered merely as the abbreviation of the word *function*, and not as a co-efficient to the letter x. In this way we include all these expressions,

$$u = x^n, \quad u = a^x, \quad u = \log x, \quad u = \cos x, \quad u = \sin x,$$

in one general expression, viz. $u = fx$, or $u = f(x)$.

When a function depends on two variable quantities x, y, which are independent of each other, such as this expression,

$$u = ax^2 + bxy + cy^2,$$

we shall express it thus,

$$u = f(x, y).$$

Here we take no notice of the constant quantity a, b, c. A like notation may be applied when three independent variables enter a function.

3. The manner in which we propose to treat this subject requires that the reader should distinctly understand what is meant by a *limit* to the value of a variable function, or a variable ratio. In the elements of geometry it is shown that the area of a circle is less than that of any regular polygon described about it; and that the greater the number of sides of the polygon, the more nearly is its area equal to that of the circle; so that any space being given, however small, a polygon may be described about the circle, which shall differ from it by less than that space. Suppose now a series of polygons to be described about a circle, each having the number of its sides greater than that which preceded it, the double for example. These will approach continually to an equality with the circle as a *limit*, which the series, however far continued, can never absolutely reach in respect of magnitude, but from which some term, and all that follow it, may differ by less than any space assignable.

In like manner, the circle is the limit of the area of all regular polygons inscribed in it; and the circumference of the circle is the limit of the perimeters of regular polygons described in it or about it.

In our article ALGEBRA (sect. 266) it has been shown, that, putting a for an arc of a circle, the fraction $\frac{a}{\sin a}$ is always greater than an unit, but that $\frac{a}{\tan a}$ is always less; farther, that the arc being supposed to decrease continually, these fractions approach to each other, and may differ by less than any assignable quantity; therefore unity, which is always between them, is their common limit. Hence it appears, that of these three quantities, an arc, its sine, and its tangent, the ratio of any two is that of equality. In the same article it has been shown that the arc a is the limit of the fractions $n \tan. \frac{a}{n}$ and $n \sin \frac{a}{n}$, supposing the number n to be increased continually.

The geometrical series

$$1 + x + x^2 + x^3 \ldots + x^{n-1}$$

is equivalent to the function $\frac{1 - x^n}{1 - x}$ (ALGEBRA, sect. 56); when x is less than 1, and n is infinitely great, then $x^n = 0$, and the function $= \frac{1}{1 - x}$; therefore, in this case, the sum of any finite number of terms of the series will always be less than $\frac{1}{1 - x}$, but will approach to it as the number of terms increases, and may differ from it by less than any assignable quantity; hence it follows that the function $\frac{1}{1 - x}$ is the limit of the sum of the series.

By the binomial theorem

$$\left(1 + \frac{x}{n}\right)^n = 1 + \frac{x}{1} + \frac{x^2}{1 \cdot 2}\left(1 - \frac{1}{n}\right)$$
$$+ \frac{x^3}{1 \cdot 2 \cdot 3}\left(1 - \frac{1}{n}\right)\left(1 - \frac{2}{n}\right) +, \text{\&c.}$$

This is true, whatever be the numerical value of n; but suppose n to be a large number, then the factors $1 - \frac{1}{n}$, $1 - \frac{2}{n}$, &c. will differ but little from unity; and they will differ the less as n is greater. Suppose now n to be indefinitely great, then these factors may be accounted each equal to an unit; and, therefore,

$$\left(1 + \frac{x}{n}\right)^n = 1 + \frac{x}{1} + \frac{x^2}{1 \cdot 2} + \frac{x^3}{1 \cdot 2 \cdot 3} +, \text{\&c.}$$

It has been shown in algebra (sect. 177) that the second member of this equation is the development of the function e^x, where e denotes the number 2·7182818, viz. the base of Napier's logarithms; therefore, if n be supposed to increase continually, the expression $\left(1 + \frac{x}{n}\right)^n$ will approach to e^x as its limit; and making $x = 1$, the limit of $\left(1 + \frac{1}{n}\right)^n = e = 2{\cdot}7182818$, a constant quantity.

4. Since the value of a function depends essentially on that of the variable, which is its basis, any change in the value of the latter will produce a corresponding change in the value of the former.

First, let the function be $u = x^2$, and let us suppose that the variable changes its value, being increased by a quantity h, and thereby becoming $x + h$; let u' denote the corresponding value of u, so that we have

$$u' = (x + h)^2 = x^2 + 2xh + h^2 = u + 2xh + h^2;$$

hence $u' - u = 2xh + h^2$.

It thus appears that, h denoting the increment of the variable x, the corresponding increment of the function, viz. $u' - u$, is $2xh + h^2$.

The algebraic expression for a ratio is a fraction whose numerator is the antecedent, and denominator the consequent. In the present case, the ratio of the increment of the function to that of its variable is

$$\frac{u' - u}{h} = 2x + h.$$

As another example, let the function be $u = x^3$; then, supposing, as before, that the variable x is increased by the quantity h, and, putting u' for the new value of the function, we have

$$u' = (x + h)^3 \begin{cases} = x^3 + 3x^2h + 3xh^2 + h^3 \\ = u + 3x^2h + 3xh^2 + h^3; \end{cases}$$

$$\frac{u' - u}{h} = 3x^2 + 3xh + h^2.$$

In this case we see that when x has increased to $x + h$, the function u has become

$$u + 3x^2h + 3xh^2 + h^3,$$

having received the increment $3x^2h + 3hx^2 + h^3$, a quantity composed of the integer powers of h. Farther, it appears that the expression for the ratio of the increments is

$$3x^2 + 3xh + h^2,$$

of which the first term $3x^2$ is entirely independent of the value of h, the increment of x.

When the function is $u = x^4$, we have, putting, as in the former examples, h for the increment of the variable, and u' for the new value of the function,

$$u' = u + 4x^3h + 6x^2h^2 + 4xh^3 + h^4,$$

$$\frac{u' - u}{h} = 4x^3 + 6x^2h + 4xh^2 + h^3.$$

From these examples it appears, that when x changes its value and becomes $x + h$, then the new value of the function

$u = x^2$ becomes $u' = u + 2xh + h^2$,
$u = x^3$ becomes $u' = u + 3x^2h + 3xh^2 + h^3$,
$u = x^4$ becomes $u' = u + 4x^3h + 6x^2h^2 + 4xh^3 + h^4$;

and in general that

$u = x^n$, any integer power of x, becomes
$u' = u + ph + qh^2 + rh^3 + sh^4 +$, &c.

the new value of the function being composed of a series of terms, the first of which is its original value, and the following terms, integer powers of the increment h, multiplied by p, q, r, &c. certain other functions of x, the forms of which depend on the original function, whence they have been derived.

Farther, it appears that

when $u = x^2$, then $\dfrac{u' - u}{h} = 2x + h$;

when $u = x^3$, $\dfrac{u' - u}{h} = 3x^2 + 3xh + h^2$;

when $u = x^4$, $\dfrac{u' - u}{h} = 4x^3 + 6x^2h + 4xh^2 + h^3$;

and, in general, that when $x = u^n$, n being any whole number, then

$$\frac{u' - u}{h} = p + qh + rh^2 + sh^3 +, \&c.$$

Thus it appears that the expression for $\dfrac{u' - u}{h}$, the ratio of the increment of the function x^n to that of its variable x, may be resolved into two parts, one, p, which is independent of the increment, and another, $qh + rh^2 + sh^3 +$, &c.; or

$$h\,(q + rh + sh^2 +, \&c.),$$

which, having h the increment as a factor, must decrease with it, and, by giving a sufficiently small value to h, may become less than any assignable quantity, so that the first term p is the limit of the ratio.

Let us consider the complex function

$$u = a + bx + cx^2.$$

When x becomes $x + h$, u becomes

$$\begin{aligned} u' &= a + b\,(x + h) + c\,(x + h)^2 \\ &= a + bx + cx^2 + (b + 2cx)\,h + ch^2, \end{aligned}$$

hence $u' - u = (b + 2cx)\,h + ch^2$,

$$\frac{u' - u}{h} = b + 2cx + ch.$$

In this case the limit of the ratio is $b + 2cx$. By a like examination of particular functions it will be found that they have all a common property, that is,

If u *be any function of a variable* x, *and if in that function* x *be supposed to change its value and become* x + h; *the corresponding new value of the function will be*

$$u' = u + ph + qh^2 + rh^3 +, \&c.$$

and the ratio of the increments of the function and its variable,

$$\frac{u' - u}{u} = p + qh + rh^2 +, \&c.;$$

an expression which, when h *is supposed to decrease continually, has for its limit the first term* p; *and this limit will be different for different functions, there being such a connection between the function and its limit, that the one may be found from the other.*

This property of the increments of a function and its variable suggests an important and extensive analytical theory, which will consist of two parts.

I. Any function of a variable quantity being proposed, to determine the limit of the ratio of the corresponding increments of the function and its variable.

II. On the other hand, having given the ratio of the increments, to find the function from which it has been derived.

These two inquiries constitute at bottom the *Direct and Inverse Method of Fluxions* of Newton, the *Differential and Integral Calculus* of Leibnitz, and the *Theory of Functions* of Lagrange. Our present subject is the direct method of fluxions, or its equivalent, the differential calculus.

5. We have seen (4), that by the transition of a function, for example, $u = x^2$, from one state of magnitude to another, by a change in the magnitude of its variable x, it acquires the new value $u' = u + 2xh + h^2$. The *whole difference* $u' - u$ between its new and first values is $2xh + h^2$. It is the first term of this difference, viz. $2xh$, that constitutes what is called the *differential* of the function from which it has been derived; and the determination of this first term for any function is the object of this first part of our calculus.

In like manner, in the function $u = x^3$, which, when x becomes $x + h$, changes to $u' = u + 3x^2h + 3xh^2 + h^3$, the whole difference between the two states of magnitude of the function is $3x^2h + 3xh^2 + h^3$, and its differential is $3x^2h$. And the whole difference between the first and succeeding value of the function $u = x^4$ is $4x^3h + 6x^2h^2 + 4xh^3 + h^4$, and its differential, is $4x^2h$. And, in general, whatever be the nature of the function u, if $x + h$ be substituted in it instead of x, and the expression thus formed be expanded into a series,

$$u + ph + qh^2 + rh^3 + sh^4, \&c.$$

the complete difference between the two states of the function is

$$ph + qh^2 + rh^3 + sh^4 +, \&c.$$

and its differential is the first term ph.

In conformity with this definition, the differential of the variable x itself will be its increment h, which, because of its use in generating the differential of the function, has been designated by a peculiar symbol, viz. dx: here the letter d is to be understood as a characteristic, not as a co-efficient. The letter d is also prefixed to the symbol for a function to denote its differential. Thus, supposing $u = x^2$, we have $du = 2xdx$, an expression which means that the differential of the function u is equal to the differential of the variable multiplied by $2x$ as a co-efficient; so also, if $u = x^3$, the equation $du = 3x^2dx$ means that the differential of u is equal to the differential of x multiplied by $3x^2$.

6. Since, when $u = x^2$, then $du = 2xdx$, this last expression may otherwise stand thus, $\frac{du}{dx} = 2x$; under this form $2x$ is the co-efficient in the expression for the differential of u, and it is on that account called the *differential co-efficient* of the function u or x^2. In like manner, when $u = x^3$, then $du = 3x^2dx$ and $\frac{du}{dx} = 3x^2$; in this case $3x^2$ is the differential co-efficient of the function $u = x^3$. The general symbol for the differential co-efficient of any function u is $\frac{du}{dx}$, and the new value of u being $u + ph + qh^2$ +, &c. we have $\frac{du}{dx} = p$, where p is some function of x, which depends on the form of the function u, and is deducible from it when its form is known.

To denote the differential of an expression formed in any way, we prefix the symbol d to the expression. Thus $d\{(a + x)(b^2 - x^2)\}$ denotes the differential of a function produced by multiplying the factors $a + x$ and $b^2 - x^2$, and $\frac{d\{(a + x)(b^2 - x^2)\}}{dx}$ serves to denote its differential co-efficient.

The definition which has been given of a differential suggests immediately this rule for finding the differential of a function of a single variable.

Substitute x + h *in the function instead of* x; *expand the expression thus formed into a series of terms composed of integer powers of* h, *and take the term which contains the first power of* h *for the differential, exchanging the letter* h *for the symbol* dx.

Thus, let the function be $u = ax + bx^2$, in which a and b are constants, then, putting $x + h$ for x, and u' for the new value of u, we have

$$u' \left\{ \begin{array}{l} = a(x + h) + b(x+h)^2 \\ = ax + bx^2 + (a + 2bx)h + bh^2 \\ = u + (a + 2bx)h + bh^2. \end{array} \right.$$

Here du, the differential of the function, is $(a + 2bx)h$, or $(a + 2bx)\,dx$, and $\frac{du}{dx} = a + 2bx$ the differential co-efficient.

7. The rule given in last article, for determining the differential of a function, supposes that we have methods by which any function may be expanded into a series of terms, into each of which some integer power of the increment h enters only as a factor. It is sufficient for our purpose, however, if we can find that term of the series which contains the simple power of h; and this can in general be found easier than the general development, which indeed may be the very thing to be investigated by the calculus. Now we have seen (4) that the co-efficient of this term is the expression for the limit of the ratio of the corresponding increments of a function and its variable, and the same quantity is the differential co-efficient of the function (6), therefore the determination of the differential of a function is the same thing as the determination of the limit of the ratio of the increments.

Direct Method.

Let the function be $u = \frac{a^2}{x}$; then $u' = \frac{a^2}{x + h}$, and

$$u' - u = \frac{a^2}{x + h} - \frac{a^2}{x} = \frac{-a^2h}{x(x + h)};$$

and the limit of the ratio of the increments is

$$\frac{u' - u}{h} = \frac{-a^2}{x(x + h)}.$$

Now, without expanding the expression for the limit, it is obvious that as h decreases, that expression approaches to $-\frac{a^2}{x^2}$, which is therefore $\frac{du}{dx}$, the differential co-efficient of the function; hence $du = -\frac{a^2\,dx}{x^2}$. In like manner, u being the general expression for any function, and $u' = u + ph + qh^2 +$, &c. its expanded value when $x + h$ is put instead of x, we have

$$\frac{u' - u}{h} = p + qh +, \&c.$$

$$\text{and limit of } \frac{u' - u}{h} = p = \frac{du}{dx}, \text{ and } du = pdx.$$

According to this view of the subject, *the differential calculus is the finding of the ratios of the simultaneous increments of a function and of the variable on which it depends.*

The process of calculation by which the differential of any function u is found, may be regarded as a particular operation performed on quantity, analogous to the elementary operations of algebra; and it may, like these, be distinguished by a particular name accordingly. The result of the process being the *differential*, the process itself is called *differentiation*, and to perform the process on a function is to *differentiate* the function.

8. It is material to observe, that the limit of the ratio of the increments of a function and its variable are the very same, whichever of the two be considered as a function of the other. Thus, u being a function of x, when x becomes $x + h$, u becomes $u + ph + qh^2 + rh^3 +$, &c. p, q, r, &c. being functions of x, deducible from the function u. Let us put

$$k = ph + qh^2 + rh^3 +, \&c.$$

so that the contemporaneous increments of x and u are h and k. Now, from the value of k, by the reversion of series (ALGEBRA, art. 163), we find

$$h = \frac{1}{p}\,k - \frac{q}{p^3}\,k^2 +, \&c.$$

So that, regarding x as a function of u, when u becomes $u + k$, x becomes

$$\frac{1}{p}\,k - \frac{q}{p^3}\,k^2 +, \&c.$$

and the general expression for the ratio of the increments is

$$\frac{h}{k} = \frac{1}{p} - \frac{q}{p^3}\,k +, \&c.$$

which has for its limit $\frac{1}{p}$, and the limit of the ratio $\frac{k}{h}$ is, as before, $= p$.

9. It is easy to see that two equal functions must have equal differentials; for whatever be the value of the va-

riable on which they depend, it must necessarily happen that the respective changes they receive in consequence of the change which is attributed to the variable must also be equal. Thus, if u and v be two functions, such, that $u = v$, whatever may be the value of x; and if, when x becomes $x + h$, then u becomes u', and v becomes v', we shall have $u' = v'$, and $u' - u = v' - v$, and

$$\frac{u' - u}{h} = \frac{v' - v}{h}.$$

If then p and q denote the limits of these ratios, $p = q$ and $pdx = qdx$, that is, $du = dv$.

From this it follows, that under whatever form a function appears, its differential is the very same quantity. For example, the differential of $x^3 + a^3$ will be identical with the differential of $(x + a)(x^2 - ax + a^2)$, its equal.

The converse of this proposition is not generally true, and we should be wrong in affirming that two equal differentials belong to equal functions. For, let $u = a + bx$ be a function of x, then, substituting $x + h$ for x, and putting u' for the new value of u, we have $u' = a + bx + bh = u + bh$, and $\frac{u' - u}{h} = b$.

We see here that the constant a does not enter into the limit of the ratio of the increments, which would therefore be the very same for the function $u = bx$; hence it follows that the differential bdx belongs alike to $a + bx$, and to bx. Thus it appears, that in differentiating any function whatever, all the constant quantities combined with it, either by addition or subtraction, disappear. With respect to those which are connected by multiplication and division, they enter the result as co-efficients.

10. The differential of any function of a variable x may be found by the general methods indicated in article 6; but it is convenient to have rules adapted to particular cases.

Let r and s be two functions of a variable x. It is proposed to investigate a rule for finding the differential of $u = rs$, their product.

Suppose that by the substitution of $x + h$ for x in the functions r and s, and their expansion, they become $r' = r + ph + qh^2 +$, &c. $s' = s + p'h + q'h^2 +$, &c.

In these expressions, p, q, &c. represent functions of x, derived from r; and p', q', &c. other functions of x derived from s. Corresponding to these let u' denote $r's'$, the new value of the product $rs = u$. By actual multiplication we find

$u' = r's' = rs + (rp' + sp)h + (rq + pp' + sq)h^2 +$, &c.

Hence, putting u for rs, also transposing and dividing by h, there is got

$$\frac{u' - u}{h} = rp' + sp + (rq' + pp' + sq)h +, \&c.$$

The terms rp' and sp in the second member of this equation are functions of x, which are independent of the function h; the following terms are all multiplied by h, therefore they decrease and vanish with it. So that

$$\text{limit of ratio } \frac{u' - u}{h} = rp' + sp.$$

$$\text{Now } p = \text{limit of } \frac{r' - r}{h}, \text{ and } q = \text{limit of } \frac{s' - s}{h}.$$

Instead of the limits of the ratios, let us put the differential co-efficients of the functions u, r, s (art. 6), and we find

$$\frac{du}{dx} = r\frac{ds}{dx} + s\frac{dr}{dx},$$

$$\text{and } du = rds + sdr.$$

Hence we have this rule, *To find the differential of the product of two functions, multiply the differential of each by the differential of the other function, and add the products.*

11. Since, when $u = rs$, we have $du = sdr + rds$, it follows that

$$\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s}.$$

If we suppose $u = rtv$, the product of three factors, by putting $s = tv$, we have $u = rs$, and

$$\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s};$$

but since $s = tv$, we have for the same reason

$$\frac{ds}{s} = \frac{dt}{t} + \frac{dv}{v};$$

$$\text{therefore } \frac{du}{u} = \frac{dr}{r} + \frac{dt}{t} + \frac{dv}{v}.$$

By writing the product rst instead of u, there is got, after proper reduction,

$$du = tvdr + rvdt + rtdv.$$

In general, *If a function be the product of any number of functions of a variable, its differential is the sum of the products obtained by multiplying the differential of each by the product of all the other functions.*

The same rule may also be briefly expressed in symbols, thus: whatever be the number of functions r, s, t, v,

$$d\,(rstv) = rstv\left\{\frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} + \frac{dv}{v}\right\}.$$

12. To find the differential of a fraction whose numerator and denominator are functions of a variable x; let $u = \frac{r}{s}$, then $r = us$, and

$$dr = uds + sdu,$$

and, putting for u its value $\frac{r}{s}$,

$$dr = \frac{rds}{s} + sdu;$$

$$\text{therefore, } du = \frac{sdr - rds}{s^2}.$$

Hence we have this rule: *To find the differential of a fraction; from the differential of the numerator multiplied by the denominator subtract the differential of the denominator multiplied by the numerator, and divide by the square of the denominator.*

The rule for the differential of $u = \frac{r}{s}$ may be also symmetrically expressed thus:

$$\frac{du}{u} = \frac{dr}{r} - \frac{ds}{s};$$

and in general, if $u = \frac{rst}{vy}$, then

$$\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} - \frac{dv}{v} - \frac{dy}{y}.$$

For, by what has been shown, it appears that when $u = \frac{rst}{vy}$, then

$$\frac{du}{u} = \frac{d(rst)}{rst} - \frac{d(vy)}{vy}.$$

$$\text{Now } \frac{d(rst)}{rst} = \frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t},$$

$$\text{and } \frac{d(vy)}{vy} = \frac{dv}{v} + \frac{dy}{y};$$

therefore, $\frac{du}{u} = \frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} - \frac{dv}{v} - \frac{dy}{y}$.

It also follows, from what has been shown, that if the numerator of a fraction consist of any number of factors r, s, t, and the denominator of any number v, y, then

$$d\left\{\frac{rst}{vy}\right\} = \frac{rst}{vy}\left\{\frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t} - \frac{dv}{v} - \frac{dy}{y}\right\}.$$

13. We shall next investigate a rule for the differential of any power of a function y, which may be either itself an independent variable, or else some function of another variable.

First, let $u = y^n$, n being any whole number. The function may be put under this form,

$$u = y \cdot y \cdot y \cdot y \ldots \text{ to } n \text{ terms,}$$

and then (11) we have

$$\frac{du}{u} = \frac{dy}{y} + \frac{dy}{y} + \frac{dy}{y} + \frac{dy}{y} \ldots \text{ to } n \text{ terms;}$$

that is, $\frac{du}{u} = \frac{ndy}{y}$,

$$\text{and } du = \frac{ndy}{y} u = ny^{n-1}\,dy.$$

Next, let us suppose that the function has a fractional exponent, and that $u = y^{\frac{m}{n}}$, then $u^n = y^m$,

$$\text{and } nu^{n-1}\,du = my^{m-1}\,dy, \text{ by art. 9,}$$

$$\text{and } du = \frac{m}{n}\,\frac{y^{m-1}}{u^{n-1}}\,dy;$$

$$\text{but } u = y^{\frac{m}{n}} \text{ and } u^{n-1} = y^{m - \frac{m}{n}};$$

$$\text{therefore } \frac{y^{m-1}}{u^{n-1}} = y^{\frac{m}{n} - 1},$$

$$\text{and } du = \frac{m}{n}\,y^{\frac{m}{n} - 1}.$$

Lastly, let us suppose n to be a negative whole number or fraction, so that $u = \frac{1}{y^n}$. In this case we may apply the rule for a fraction (12); and observing that the numerator here is a constant, of which the differential must be accounted $= 0$, we have

$$du = -\frac{ny^{n-1}dy}{y^{2n}} = -ny^{-n-1}dy;$$

thus it appears, that whether n be whole or fractional, positive or negative,

$$d(y^n) = ny^{n-1}dy.$$

Hence this rule: *To differentiate any power of a function, multiply it by the exponent, diminish the exponent by an unit, and multiply by the differential of the variable.*

If the function have a co-efficient, the differential must be multiplied by that co-efficient. Thus

$$d(ax^n) = nax^{n-1}\,dx.$$

The determination of the differential of a power of a variable might have been shortened by assuming the truth of the binomial theorem, as found in our article ALGEBRA, art. 160, 161. That theorem however may be derived from the differential calculus, and we shall give its investigation as one of its applications.

It frequently happens that the differential of $\sqrt{y} = y^{\frac{1}{2}}$, the square root of a function, is to be found; therefore a rule for that case will be convenient. By the general rule for a power,

$$d(y^{\frac{1}{2}}) = \tfrac{1}{2}y^{\frac{1}{2}-1}dy = \tfrac{1}{2}y^{-\frac{1}{2}}dy,$$

$$\text{that is, } d(\sqrt{y}) = \frac{dy}{2\sqrt{y}}.$$

Hence it appears that *the differential of the square root of a function is the differential of the function divided by twice its square root.*

14. Let y be a function of a variable x, and let u be a function of y; it is proposed to investigate a rule for finding the differential of u relatively to x.

Suppose x to change its value and become $x + h$, then y becomes $y' = y + ph + qh^2 + rh^3 +$, &c.; or, putting $ph + qh^2 + rh^3 +$, &c. $= k$, y becomes $y + k$. But u being a function of y, when y becomes $y + k$, then u becomes $u' = u + p'k + q'k^2 + r'k^3 +$, &c.; here p', q', r', &c. denote certain functions of y, which are independent of k and also of h. Hence, by substituting for k in this last series, its value $ph + qh^2 +$, &c., it appears that when x becomes $x + h$, u becomes

$$u' = u + p'ph + (p'q + q'p^2)\,h^2 +, \&c.$$

$$\text{and hence } \frac{u' - u}{h} = p'p + (p'q + q'p^2)h +, \&c.$$

Suppose now h to decrease continually, we have

$$\text{limit of } \frac{u' - u}{h} = p'p.$$

Now, y being a function of x, $p = \frac{dy}{dx}$, and u being considered as a function of y, $p' = \frac{du}{dy}$; but if we consider u as a function of x, then

$$\frac{du}{dx} = \text{limit } \frac{u' - u}{h} = p'p.$$

Hence it follows that

$$\frac{du}{dx} = \frac{du}{dy} \times \frac{dy}{dx},$$

$$\text{and } du = \left(\frac{du}{dy} \times \frac{dy}{dx}\right)dx.$$

Hence this rule: To find, relatively to x, the differential of u, a function of y, the quantity y being a function of x, *Find the differential co-efficient of* u *considered as a function of* y *only, and the differential co-efficient of* y *considered as a function of* x; *multiply the product of these co-efficients by the differential of* x, *and the result is the differential of* u.

It has been found that

$$\frac{du}{dy} \times \frac{dy}{dx} = \frac{du}{dx};$$

Now if we suppose that $u = x$, then this expression becomes

$$\frac{dx}{dy} \times \frac{dy}{dx} = \frac{dx}{dx} = 1;$$

and hence it appears that

$$\frac{dx}{dy} = \frac{1}{\frac{dy}{dx}}.$$

This shows that the differential co-efficient of x considered as a function of y, is the reciprocal of the differential co-efficient of y considered as a function of x, a conclusion which may also be deduced from art. 8.

15. Let v, y, z be functions of a variable x, and let it be proposed to find the differential of

$$u = a + bv + cy - ez,$$

where a, b, c, e, denote constants.

Let us suppose that when x becomes $x + h$, then

$$v \text{ becomes } v + ph + qh^2 +, \&c.$$
$$y \text{ becomes } y + p'h + q'h^2 +, \&c.$$
$$z \text{ becomes } z + p''h + q''h^2 +, \&c.$$

Let u' be the corresponding value of u, so that

$$u = \begin{cases} a + bv + cy - ez \\ + (bp + cp' - ep'')h \\ + (bq + cq' - eq'')h^2 \\ +, \&c. \end{cases}$$

Hence, putting for the first term of the second member of the equation its value u, and transposing and dividing by h, we get

$$\frac{u' - u}{h} = bp + cp' - ep'' + (bq + cq' - eq'')h, \&c.$$

And passing to the limits, observing that the limit of $\frac{u' - u}{h}$ is the differential co-efficient of u, also that p, p', and p'' are the differential co-efficients of v, y, and z respectively, we get

$$\frac{du}{dx} = \frac{bdv}{dx} + \frac{cdy}{dx} - \frac{edz}{dx},$$

$$\text{and } du = bdv + cdy - edz.$$

From this it appears that *the differential of a function made up of others simply by addition and subtraction is composed in like manner of the differentials of the several terms, each with the sign of the function from which it was derived; the differential of a constant being reckoned* = 0.

16. These rules are sufficient for the differentiation of any explicit algebraic function, and we shall now give examples.

1. Let $u = ax^5$; this is a particular case of the general function $u = ax^n$; therefore, by the rule (13) $du = 5ax^4dx$.

2. Let $u = \frac{a}{x^5} = ax^{-5}$; then $du = -5\,ax^{-6}\,dx = \frac{-5adx}{x^6}$.

3. Let $u = \sqrt{x^3} = x^{\frac{3}{2}}$; in this case $du = \frac{3}{2}x^{\frac{1}{2}}dx = \frac{3}{2}\,dx\sqrt{x}$.

4. Let $u = ax^3 + bx^2 + cx + e$;
then $du = 3ax^2dx + 2bxdx + cdx$,
or $du = (3ax^2 + 2bx + c)\,dx$.

Here the constant e, which is a term of the function, has disappeared by the differentiation.

5. Let $u = (a + bx^n)^p$; we may put $y = a + bx^n$, and then $u = y^p$; and $du = py^{p-1}dy$.

Now $y^{p-1} = (a + bx^n)^{p-1}$, and $dy = bnx^{n-1}dx$;

therefore $du = bnp\,(a + bx^n)^{p-1}\,x^{n-1}dx$.

We might have dispensed with using the symbol y, and regarded $a + bx^n$ as a single function, and u as a power of that function, and found the differential by the rule of art. 13.

As an example of the rule of art. 10, for the product of two functions,

6. Let $u = x^3\,(a + x)^2$;
put $p = x^3$, and $q = (a + x)^2$; then $u = pq$,
and $du = qdp + pdq$.

Now $dp = 3x^2dx$, and $dq = 2\,(a + x)\,dx$;
therefore $du = 3x^2\,(a + x)^2\,dx + 2x^3\,(a + x)\,dx$
$= x^2\,(a + x)\,(3a + 5x)\,dx$.

In practice, the introduction of the symbols p and q may be omitted.

7. Let $u = x\,(1 + x)\,(1 + x^2)$. In this case, u is the product of three functions; therefore, by the rule of art. 11, $du = (1 + x)\,(1 + x^2)\,dx + x\,(1 + x^2)\,dx + 2x^2\,(1 + x)\,dx$. This, when abbreviated by multiplication, becomes $du = (1 + 2x + 3x^2 + 4x^3)\,dx$.

We might have proceeded otherwise by the rule

$$d\,(rst) = rst\left\{\frac{dr}{r} + \frac{ds}{s} + \frac{dt}{t}\right\};$$

accordingly, we would have had

$$du = x\,(1 + x)\,(1 + x^2)\left\{\frac{dx}{x} + \frac{dx}{1 + x} + \frac{2xdx}{1 + x^2}\right\},$$

an expression reducible to the former.

8. As an example of a fractional function, let $u = \frac{x}{1 + x^2}$; we have, following the rule of art. 12,

$$du = \frac{(1 + x^2)\,dx - 2\,x^2dx}{(1 + x^2)^2} = \frac{(1 - x^2)dx}{(1 + x^2)^2}.$$

9. Again, let $u = \frac{x^3 + x}{x^4 - x^2 + 1} = \frac{x(x^2 + 1)}{x^4 - x^2 + 1}$; this may exemplify the rule

$$d\left(\frac{rs}{t}\right) = \frac{rs}{t}\left\{\frac{dr}{r} + \frac{ds}{s} - \frac{dt}{t}\right\}.$$

Accordingly, making $x = r$, $x^2 + 1 = s$, $x^4 - x^2 + 1 = t$, we have

$$du = \frac{x^3 + x}{x^4 - x^2 + 1}\left\{\frac{dx}{x} + \frac{2xdx}{1 + x^2} - \frac{(4x^3 - 2x)\,dx}{x^4 - x^2 + 1}\right\}.$$

This by reduction becomes

$$du = \frac{-\{x^6 + 4x^4 - 4x^2 - 1\}dx}{(x^4 - x^2 + 1)^2}.$$

10. As an example of the rule in art. 14, let $u = 3y^2$, and $y = x^3 + ax$; then

$$\frac{du}{dy} = 6y, \quad \frac{dy}{dx} = 3x^2 + a;$$

$$\frac{du}{dy}\cdot\frac{dy}{dx} = 6y\,(3x^2 + a) = 18\,x^2y + 6ay,$$

$$\text{and } du = \frac{du}{dy}\cdot\frac{dy}{dx}\cdot dx = 18x^2ydx + 6aydx.$$

We may in such an example proceed otherwise, thus; because $u = 3y^2$, $du = 6ydy$;
and since $y = x^3 + ax$, $dy = 3x^2 + adx$,
substitute this value of dy in the expression for du, and it becomes

$$du = 18x^2y + 6aydx,$$

the same as before.

17. The subjects which are to follow require the application of the binomial theorem, we shall therefore give its investigation, as the first application of the calculus.

Supposing n to be any number whatever, whole or fractional, positive or negative, it is easy to infer, from the consideration of particular cases, that

$$(1 + x)^n = 1 + \mathrm{A}x + \mathrm{B}x^2 + \mathrm{C}x^3 + \mathrm{D}x^4 +, \&c.,$$

the co-efficients A, B, C, &c., in the series being numbers altogether independent of x, and deducible from the index n alone. The expression $(1 + x)^n$ and its development being equal for all values of x, they form an identical equation, and must have equal differentials, hence (art. 9) we have, taking the differential of each term,

$$n(1 + x)^{n-1}\,dx = \mathrm{A}dx + 2\mathrm{B}xdx + 3\mathrm{C}x^2dx + 4\mathrm{D}x^3dx +, \&c.$$

Leaving now dx out of each term, and multiplying both sides by $1 + x$, the result is

$$n(1 + x)^n = \mathrm{A} + (\mathrm{A} + 2\mathrm{B})x + (2\mathrm{B} + 3\mathrm{C})x^2 + (3\mathrm{C} + 4\mathrm{D})x^3 +, \&c.$$

But from the assumed series we have

$$n(1 + x)^n = n + n\mathrm{A}x + n\mathrm{B}x^2 + n\mathrm{C}x^3 +, \&c.$$

Now the terms of these two expansions of $n(1 + x)^n$ must be identical; therefore

$$\left.\begin{aligned} \mathrm{A} &= n, \\ \mathrm{A} + 2\mathrm{B} &= n\mathrm{A}, \\ 2\mathrm{B} + 3\mathrm{C} &= n\mathrm{B}, \\ 3\mathrm{C} + 4\mathrm{D} &= n\mathrm{D}, \\ &\&c. \end{aligned}\right\}\text{ and hence }\left\{\begin{aligned} \mathrm{A} &= n; \\ \mathrm{B} &= \frac{(n-1)}{2}\mathrm{A}; \\ \mathrm{C} &= \frac{n-2}{3}\mathrm{B}; \\ \mathrm{D} &= \frac{n-3}{4}\mathrm{C}; \\ &\&c. \end{aligned}\right.$$

By substituting for A its value in B, and for B the resulting value in C, and so on, there is found

$$(1+x)^n=1+\frac{n}{1}x+\frac{n(n-1)}{1\,.\,2}x^2+\frac{n(n-1)(n-2)}{1\,.\,2\,.\,3}x^3+\text{\&c.}$$

and again, by putting $\frac{v}{a}$ instead of x, and multiplying both sides of the equation by a^n, we get

$$(a+x)^n=a^n+\frac{n}{1}a^{n-1}x+\frac{n(n-1)}{1\,.\,2}a^{n-2}x^2$$
$$+\frac{n(n-1)(n-2)}{1\,.\,2\,.\,3}a^{n-3}x^3+,\text{\&c.}$$

18. In the investigation of the binomial theorem we have employed a principle of analysis of continual use in the calculus, namely, that in such an equation as this (called an *Identical Equation*),

$a+bx+cx^2+ex^3+$&c., $=A+Bx+Cx^2+Ex^3+$ &c.(1.)

in which a, b, c, &c., A, B, C, &c. are constants, and x is variable; in order that the equation may hold universally true, it is necessary that $a=A$, $b=B$, $c=C$, $e=E$, &c. For since x is indeterminate, we may suppose it to decrease until it vanish; then all the terms into which it enters also vanish, and we have $a=A$; therefore, leaving these equal terms out of both sides of (1), and dividing all the remaining terms by x, we get

$b+cx+ex^2+$, &c., $=B+cx+Ex^2+$, &c. (2.)

By proceeding with this equation as with the former, we obtain $b=B$, $c=C$, $e=E$, &c., and so on.

19. We come now to the investigation of the differentials of transcendental functions of a variable, and begin with the exponential function $u=a^x$, the exponent x being variable, and the quantity a constant. Assuming that when x becomes $x+h$, u becomes u', we have

$$u=a^x,\quad u'=a^{x+h}=a^x\ a^h;$$

therefore, $u'-u=a^x\ a^h-a^x=a^x(a^h-1)$;

$$\text{and } \frac{u'-u}{h}=a^x\frac{a^h-1}{h}.$$

The determination of the limit of the ratio of the increments requires that we determine the limit to which the value of the fraction $\frac{a^h-1}{h}$ tends when h is supposed to decrease continually. Let us put $a=1+c$; by the binomial theorem (art. 17),

$$a^h=(1+c)^h=1+hc+\frac{h(h-1)}{1\,.\,2}c^2+\frac{h(h-1)(h-2)}{1\,.\,2\,.\,3}c^3+\text{\&c.}$$

$$\text{therefore, } \frac{ah-1}{h}=c+\frac{h-1}{2}c^2+\frac{(h-1)(h-2)}{2\,.\,3}c^3+\text{\&c.}$$

Now h being supposed to decrease continually, the second side of this formula manifestly approaches to

$$c-\tfrac{1}{2}c^2+\frac{-1\,.-2}{2\,.\,3}c^3+\frac{-1\,.-2\,.-3}{2\,.\,3\,.\,4}c^4+\text{\&c.}$$

that is, to $c-\frac{1}{2}c^2+\frac{1}{3}c^3-\frac{1}{4}c^4+$, &c.

$=(a-1)-\frac{1}{2}(a-1)^2+\frac{1}{3}(a-1)^3-\frac{1}{4}(a-1)^4+$, &c.

Now it has been shown in ALGEBRA (art. 173), and will be proved in the sequel, that this series expresses Napier's logarithm of the number a. Therefore,

$$\text{limit of } \frac{a\ -1}{h}=\text{Nap. log } a,$$

$$\text{and hence, } \frac{du}{dx}=\text{limit } \frac{u'-u}{h}=a^x(\text{Nap. log } a),$$

$$\text{and } du=(\text{Nap. log } a)\ a^x dx.$$

We have now this rule for differentiating a function which is a variable power of a constant quantity.

Multiply the function by the differential of the variable index, and by Napier's log. of the constant quantity.

Note.—The logarithm of a number a, in any system whatever, will in what follows be expressed by the abbreviation log a; but when the system is that of Napier, we shall denote it thus, l. a.

20. To find the differential of the transcendental $u=\log x$, the base of the system being a. By the definition of a logarithm (ALGEBRA, art. 165),

$$x=a^u,$$

and, supposing that x becomes $x+h$, and that u becomes u',

$$x+h=a^{u'};$$

therefore, $h=a^{u'}-a^u=a^u(a^{u'-u}-1)=x(a^{u'-n}-1)$;

and hence, making $k=u'-u$,

$$\frac{h}{u'-u}=\frac{x(a^k-1)}{k};$$

$$\text{and } \frac{u'-u}{h}=\frac{1}{x}\cdot\frac{k}{a^k-1}.$$

Passing now to the limits of the two sides of the equation, and observing (as was proved in last article) that k being supposed to decrease continually,

$$\text{limit of } \frac{k}{a^k-1}=\frac{1}{\text{l.}\,a},$$

$$\text{we have } \frac{du}{dx}=\frac{1}{\text{l.}\,a}\cdot\frac{1}{x}.$$

Let M denote the constant factor, viz. the reciprocal of Napier's logarithm of the base of the system of logarithms, which is the modulus of the system (ALGEBRA, art. 172), and we have

$$du=\frac{Mdx}{x};$$

That is, *The differential of the logarithm of a number is found by multiplying the differential of the number by the modulus of the system and dividing by the number.*

Note.—In Napier's system $M=1$.

21. The differentials of the trigonometrical functions sin x and cos x are next to be investigated.

Let $u=\sin x$, and $u'=\sin(x+h)$; then (ALGEBRA, 240),

$u'-u=\sin(x+h)-\sin x=2\cos(x+\frac{1}{2}h)\sin\frac{1}{2}h$,

$$\text{and } \frac{u'-u}{h}=\cos(x+\tfrac{1}{2}h)\frac{\sin.\frac{1}{2}h}{\frac{1}{2}h}.$$

Observing now that h being understood to decrease continually until it vanish, the limit of $\cos(x+\frac{1}{2}h)$ is $\cos x$, and the limit of $\frac{\sin\frac{1}{2}h}{\frac{1}{2}h}=1$ (ALGEBRA, 266), we have

$$\frac{du}{dx}=\text{limit } \frac{u'-u}{h}=\cos x;$$

$$\text{and } du=dx\cos x.$$

Next let $u=\cos x$, and $u'=\cos(x+h)$ we have now

$u'-u=\cos(x+h)-\cos x=-2\sin(x+\frac{1}{2}h)\sin\frac{1}{2}h$;

$$\frac{u'-u}{h}=-\sin(x+\tfrac{1}{2}h)\frac{\sin\frac{1}{2}h}{\frac{1}{2}h}.$$

Passing now to the limits by supposing h to decrease continually,

$$\frac{du}{dx}=\text{limit } \frac{u'-u}{h}=-\sin x;$$

$$\text{and } du=-dx\sin x.$$

Hence it appears that *The differential of the sine of an arc is the product of the differential of the arc and its cosine:*

and that the differential of the cosine is the product of the differential of the arc and its sine with the sign — prefixed.

Note.—The negative sign indicates, that while the arc increases the cosine decreases when it is positive.

The differential of the cosine might have been found otherwise, by regarding it as a function of the sine. Thus, putting v for the sine, and y for the cosine; because $y^2 = 1 - v^2$, by differentiating, $ydy = -vdv$; now x being the arc, $dv = ydx$; therefore $ydy = -vydx$, and $dy = -vdx$.

22. The functions $u = \tan x, u = \cot x$, &c. may be considered as formed from the elementary functions $\sin x$ and $\cos x$.

(1.) Let $u = \tan x = \dfrac{\sin x}{\cos x}$, then (art. 12 and 20),

$$du = \frac{d(\sin x)\cos x - d(\cos x)\sin x}{\cos^2 x}$$

$$= \frac{(\cos^2 x + \sin x^2)dx}{\cos^2 x} = \frac{dx}{\cos^2 x}.$$

Hence, again, $du = dx \sec^2 x = dx(1 + \tan^2 x)$.

(2.) In the same way, if $u = \cot x$, we find

$$du = \frac{-dx}{\sin x^2} = -dx \operatorname{cosec}^2 x = -dx(1 + \cot^2 x).$$

(3.) Let $u = \sec x = \dfrac{1}{\cos x}$; then

$$du = \frac{dx \sin x}{\cos^2 x} = dx \tan x \sec x.$$

(4.) Let $u = \operatorname{cosec} x = \dfrac{1}{\sin x}$;

$$du = -\frac{dx \cos x}{\sin^2 x} = dx \cot x \operatorname{cosec} x.$$

23. Corresponding to the direct functions

$u = \sin x$, $u = \cos x$, &c.

there are the reverse functions,

$u = \text{arc}(\sin = x)$, $u = \text{arc}(\cos x)$, &c.

The first, viz. the arc whose sine is x, is sometimes by British writers expressed thus; $u = \sin^{-1} x$; and the second, the arc whose cosine is x, thus; $u = \cos x^{-1}$.

(1.) Let $u = \text{arc}(\sin = x) = \sin^{-1} x$;

then $x = \sin u$; and $dx = du \cos u = du\sqrt{1 - x^2}$;

$$\text{and } du = \frac{dx}{\sqrt{1 - x^2}}.$$

(2.) Let $u = \text{arc}(\cos = x) = \cos^{-1} x$:

then $x = \cos u$; and $dx = -du \sin u = -du\sqrt{1 - x^2}$;

$$\text{and } du = \frac{-dx}{\sqrt{1 - x^2}}.$$

(3.) Let $u = \text{arc}(\tan = x) = \tan^{-1} x$:

then $x = \tan u$ and $dx = du(1 + x^2)$;

$$\text{and } du = \frac{dx}{1 + x^2}.$$

(4.) Let $u = \text{arc}(\cot = x) = \cot^{-1} x$;

then $x = \cot u$ and $dx = -du(1 + u^2)$,

$$\text{and } du = \frac{-dx}{1 + x^2}.$$

(5.) Let $u = \text{arc}(\sec = x) = \sec^{-1} x$;

then $x = \sec u$; and $dx = du \sec u \tan u = du\, x\sqrt{x^2 - 1}$,

$$\text{and } du = \frac{dx}{x\sqrt{x^2 - 1}}.$$

(6.) Let $u = \text{arc}(\operatorname{cosec} = x) = \operatorname{cosec}^{-1} x$, then, proceeding as in the foregoing examples, we find

$$du = \frac{-dx}{x\sqrt{x^2 - 1}}.$$

24. Having now found rules for the differentiation of the elementary transcendentals and trigonometrical functions, we proceed to exemplify their application to the differentiation of complex functions.

(1.) Let the function be $u = x^y$, that is a variable x raised to a power y, a function of the variable.

By the theory of logarithms $\text{l.}\, u = y\, \text{l.}\, x$.

Put $v = \text{l.}\, u$ and $z = \text{l.}\, x$; then $v = yz$;

and $dv = ydz + zdy$ (art. 10).

$$\text{Now } dv = d(\text{l.}\, u) = \frac{du}{u}; \text{ and } dz = d(\text{l.}\, x) = \frac{dx}{x}\ (20);$$

$$\text{therefore, } \frac{du}{u} = \frac{ydx}{x} + \text{l.}\, x \,.\, dy,$$

$$\text{and } du \begin{cases} = u\left\{\dfrac{y}{x}dx + \text{l.}\, x \,.\, dy\right\} \\ = x^y\left\{\dfrac{y}{x}dx + \text{l.}\, x \,.\, dy\right\} \\ = x^{y-1}\, ydx + x^y\, \text{l.}\, x \,.\, dy. \end{cases}$$

(2.) If $u = x^x$, then, by last example,

$$du = x^x\left\{1 + \text{l.}\, x\right\} dx.$$

(3.) Let $u = a^{b^x}$; put $b^x = y$, then $u = a^y$,

and $du = \text{l.}\, a\, a^y dy$, also $dy = \text{l.}\, b \,.\, b^x\, dx$ (19);

therefore $du = \text{l.}\, a \,.\, \text{l.}\, b \,.\, a^{b^x}\, dx$.

In the following examples we shall suppose the logarithms to be those of Napier's system.

(4.) Let $u = \text{l.}\left\{\dfrac{x}{\sqrt{a^2 + x^2}}\right\}$. Making $\dfrac{x}{\sqrt{a^2 + x^2}} = z$,

we have $du = \dfrac{dz}{z}$; but

$$dz = \frac{dx\sqrt{a^2 + x^2} - \dfrac{x^2 dx}{\sqrt{a^2 + x^2}}}{a^2 + x^2} = \frac{a^2 dx}{(a^2 + x^2)^{\frac{3}{2}}};$$

$$\text{therefore } du = \frac{a^2 dx}{x(a^2 + x^2)}.$$

(5.) Let $u = \text{l.}\left\{\dfrac{\sqrt{1 + x} + \sqrt{1 - x}}{\sqrt{1 + x} - \sqrt{1 - x}}\right\}$;

put $y = \sqrt{1 + x} + \sqrt{1 - x}$, $z = \sqrt{1 + x} - \sqrt{1 - x}$;

then $u = \text{l.}\left(\dfrac{y}{z}\right) = \text{l.}\,(y) - \text{l.}\,(z)$;

$$\text{and } du = \frac{dy}{y} - \frac{dz}{z}.$$

$$\text{Now } dy = \frac{dx}{2\sqrt{1 + x}} - \frac{dx}{2\sqrt{1 - x}}$$

$$= \frac{-dx}{2\sqrt{1 - x^2}}\left\{\sqrt{1 + x} - \sqrt{1 - x}\right\} = \frac{-zdx}{2\sqrt{1 - x^2}},$$

$$\text{and } dz = \frac{dx}{2\sqrt{1 + x}} + \frac{x}{2\sqrt{1 - x}}$$

$$= \frac{dx}{2\sqrt{1 - x^2}}\left\{\sqrt{1 + x} + \sqrt{1 - x}\right\} = \frac{ydx}{2\sqrt{1 - x^2}};$$

$$\text{therefore } \frac{dy}{y} - \frac{dz}{z} = \frac{-2dx}{2y\sqrt{1 - x^2}} - \frac{ydx}{2z\sqrt{1 - x^2}}$$

$$= \frac{-(y^2 + z^2)dx}{2yz\sqrt{1 - x^2}};$$

and observing that

$$y^2 + z^2 = u, \quad yz = 2x,$$

we find at last $du = \frac{-dx}{x\sqrt{1 - x^2}}$.

In the next two examples we shall merely put down the results

(6.) $$u = \text{l.}\left\{x - \sqrt{1 + x^2}\right\}$$

$$du = \frac{dx}{\sqrt{1 + x^2}},$$

(7.) $$u = \text{l}\cdot\left\{\frac{\sqrt{1 + x^2} + x}{\sqrt{1 + x^2} - x}\right\}$$

$$du = \frac{dx}{\sqrt{1 + x^2}}.$$

25. As examples combining logarithmic and angular functions:

(1.) Let $u = \text{l. sin } n$;

then $du = \frac{dx \cos x}{\sin x} = dx \tan x$.

(2.) Let $u = \text{l. } (\tan x)$;

$$du \begin{cases} = \dfrac{dx \sec^2 x}{\tan x} = \dfrac{dx}{\sin x \cos x} \\ = \dfrac{2dx}{\sin 2x}. \end{cases}$$

26. As examples of complex angular functions:

(1.) Let $u = \tan^{-1} x$; that is, let u be the arc whose tangent is x, and let $z = \cos nu \cos^n u$.

It is proposed to find the differential co-efficient $\frac{dz}{dx}$.

In the first place, $du = \frac{dx}{\sec^2 u} = dx \cos^2 u$,

$$dz \begin{cases} = -ndu\,(\sin nu \cos^n u + \cos nu \sin u \cos^{n-1} u) \\ = -ndu \cos^{n-1} u\,(\sin nu \cos u + \cos nu \sin u) \\ = -ndu \cos^{n-1} u \sin (n + 1)\,u, \end{cases}$$

and $\frac{dz}{dx} = -n \sin (n + 1)\,u \cos^{n+1} u$.

(2.) Next, u being the same function of x as before,

let $z = \sin nu \cos^n u$,

to find the differential co-efficient $\frac{du}{dx}$.

In this case,

$$dz \begin{cases} = ndu\,(\cos nu \cos^n u - \sin nu \sin u \cos^{n-1} u) \\ = ndu \cos^{n-1} u\,(\cos nu \cos u - \sin nu \sin u) \\ = ndu \cos^{n-1} u \cos (n + 1)\,u, \end{cases}$$

and $\frac{dz}{dx} = n \cos (n + 1)\,u \cos^{n+1} u$.

Successive Differentiations.

27. A function of a variable, when differentiated, produces a new function, viz. its differential co-efficient. This in its turn may be differentiated, and there will be produced another differential co-efficient, which will stand in the same relation to the former as that did to the original function. By another differentiation, a third differential co-efficient may be formed; and so on continually, unless some differential co-efficient come out $= 0$.

For example, from the function $u = x^n$, we deduce $\frac{du}{dx} = n\,x^{n-1}$: putting now $p = nx^{n-1}$, we hence derive the differential co-efficient $\frac{dp}{dx} = n\,(n-1)\,x^{n-2}$; and putting $q = n(n-1)x^{n-2}$, we find $\frac{dq}{dx} = n(n-1)(n-2)x^{n-3}$. We may proceed in this way, until the result of a differentiation be a constant, and then the process will stop; but in some cases it may be continued indefinitely.

There is an appropriate notation to express the relation in which the successive differentials, p, q, &c. stand to the original function u, from which they have been derived: since

$$p = \frac{du}{dx}, \text{ and } q = \frac{dp}{dx}, \text{ therefore } q = \frac{d\left(\frac{du}{dx}\right)}{dx}:$$

The symbol $d\left(\frac{du}{dx}\right)$ will be more simply expressed by $d^2u\,.\,dx$; and thus we have

$$p = \frac{du}{dx},\; q = \frac{dp}{dx} = \frac{d^2u}{dx^2};$$

so that by the expression $q = \frac{d^2u}{dx^2}$, it is to be understood that q is the result of two differentiations performed on the function u, the differential of the variable, viz. dx, being considered as constant.

From the function q we may now deduce

$$r = \frac{dq}{dx} = \frac{d^3u}{dx^3},$$

and so on continually; but the different import of the characters d^3u and dx^3 must be carefully attended to; the former implies that the operation of differentiation has been performed three times on the function u, and the latter denotes the third power of dx. The combination of the two, $\frac{d^3u}{dx^3}$, expresses the function that results from the three differentiations, in each of which the factor dx has been left out, and the final result divided by its third power, or, if retained, that it has been regarded as constant.

(1.) As a particular case of the function $u = ax^n$, let $u = ax^5$;

$$\text{then } \frac{du}{dx} = 5ax^4, \quad \frac{d^2u}{dx^2} = 4{\cdot}5ax^3,$$

$$\frac{d^3u}{dx^3} = 3{\cdot}4{\cdot}5ax^2, \quad \frac{d^4u}{dx^4} = 2{\cdot}3{\cdot}4{\cdot}5ax,$$

$$\frac{d^5u}{d^5x} = 2{\cdot}3{\cdot}4{\cdot}5a.$$

In this example we have come to a differential co-efficient which is a constant, and the series stops; but if the index of the power x^n be a fraction or negative, the series may be continued indefinitely.

The expression $\frac{du}{dx}$ is called the *first* differential co-efficient of the function u, or the differential co-efficient of the *first order*; those which follow are called the *second*, *third*, &c. or the differential co-efficients of the *second*, *third*, &c. orders.

In the case of the function $u = x^5$, writers on the calculus of fluxions call $du = 5x^4dx$ the *first* fluxion of the function; $d^2u = 20x^3dx^2$ its *second* fluxion; $d^3u = 60x^2dx^3$ its *third* fluxion; and so on, the terms of the series constituting the different *orders* of fluxions.

Other examples of successive differentiation:

(2.) Let $u = a^x$; then (article 9), $\frac{du}{dx} = \text{l}.a\, a^x$,

$\frac{d^2u}{dx^2} = (\text{l}.a)^2\, a^x$, $\frac{d^3x}{dx^3} (\text{l}.a)^3\, a^x$, $\frac{d^4x}{dx^4} = (\text{l}.a)^4\, a^x$, &c.

(3.) Let $u = \log. x$; then (art. 20) $\frac{du}{dx} = \frac{\text{M}}{x}$,

$\frac{d^2u}{dx} = -\frac{\text{M}}{x^2}$, $\frac{d^3u}{dx^3} = -\frac{1\cdot2\text{M}}{x^3}$, $\frac{d^4u}{dx^4} = \frac{1\cdot2\cdot3\text{M}}{x^4}$, &c.

(4.) Let $u = \sin x$; then $\frac{du}{dx} = \cos x$,

$\frac{d^2u}{dx^2} = -\sin x$, $\frac{d^3u}{dx^3} = -\cos x$, $\frac{d^4u}{dx^4} = \sin x$, &c.

(5.) Let $u = \cos x$; then $\frac{du}{dx} = -\sin x$,

$\frac{d^2u}{dx^2} = -\cos x$, $\frac{d^3u}{dx^3} = \sin x$, $\frac{d^4u}{dx^4} = \cos x$, &c.

(6.) Let $u = \frac{a^2}{a^2 + x^2}$; then $\frac{du}{dx} = \frac{-2a^2x}{(a^2+x^2)^2}$,

$$\frac{d^2u}{dx^2} = \frac{-2a^4 + 6a^2x^2}{(a^2 + x^2)^3},$$

$$\frac{d^3u}{dx^3} = \frac{24a^4x - 24a^4x^3}{(a^2 + x^2)^4}, \text{ \&c.}$$

Taylor's Theorem.

28. We have assumed for the foundation of the differential calculus an important analytical principle, first particularly recognised by Euler, viz. Let $f(x)$ denote any function of a variable quantity x; if instead of x there be substituted $x + h$, h being any indeterminate quantity, so that the function becomes $f(x + h)$, this new value may always be expanded into a series of this form,

$$f(x) + ph + qh^2 + rh^3 +, \text{\&c.},$$

in which the quantities p, q, &c. are new functions of x derived from the primitive function, and independent of the indeterminate quantity h.

29. The truth of this principle has been exemplified by induction from particular cases. Lagrange has, however, given a demonstration of it in his *Théorie des Fonctions*, which is to the following effect:

In the first place, the development of the function $(x + h)$ cannot contain any fractional power of h, so long as x is entirely indeterminate. For the radicals of h can only come from radicals in the primitive function; and it is manifest that the substitution of $x + h$ instead of x can neither increase nor diminish their number, nor change their nature, while x and h are indeterminate. On the other hand, by the theory of equations, every radical expression has as many different values as there are units in its exponent; from which it follows, that every irrational function has as many distinct values as there are combinations of the different values of the radicals which it contains. Therefore, if the development of the function $f(x + h)$ could contain a term of the form $uh^{\frac{m}{n}}$, the function fx must necessarily be irrational, and contain a certain number of different values, which must be the same for its development; but this development being represented by the series $f(x) + ph + qh^2 +$, &c. $+ uh^{\frac{m}{n}} +$, &c. every value of the function $f(x)$ (the first term) might be combined with each of the n values of the radical $\sqrt[n]{x^m}$, so that the function $f(x + h)$ expanded would have more values than the same function unexpanded, which is impossible.

This demonstration is general and rigorous so long as x and h continue indeterminate; but it fails if determinate values be given to x, for it may happen that these values may destroy some radicals in the function $f(x)$, which may yet exist in the function $f(x + h)$.

30. It being proved that the development of the function cannot have any fractional powers of h, it is easy to be assured that it cannot contain negative powers. For if among the terms one had the form $\frac{r}{h^m}$, m being a positive integer number, then, in making $h = 0$, that term would become infinite, and the function $(x + h)$, and of course $f(x)$, would in this case be infinite, which cannot be, unless a particular value be given to x. Thus it is clearly established that the development of the function can contain neither fractional nor negative exponents.

31. The general form of the development of the function, viz.

$$f(x + h) = f(x) + ph + qh^2 + rh^3 +, \text{\&c.}$$

being thus ascertained, the next question is, what is the law of relation between the original function $f(x)$ and the functions p, q, r, &c. which are derived from it? We owe the discovery of this relation to a celebrated English mathematician, Brooke Taylor, who gave it in his *Methodus Incrementorum*, published in the year 1715 in the form of an analytical theorem, which is now called by his name: we shall now give its investigation. The following is that of Lagrange.

Let $f(x) = u$ be any function of x;
then, supposing x to become $x + h$, u becomes

$$f(x + h) = u + ph + qh^2 + rh^3 + sh^4 +, \text{\&c.}$$

Suppose now that x changes again its value, and becomes $x + k$, and here k, like h, is independent of x. Then

$$f(x + h) \text{ becomes } f(x + h + k).$$

There are two ways of finding what the series

$$f(x + h) = u + ph + qh^2 + rh^3 + sh^4 +, \text{\&c.}$$

becomes, when $x + h$ becomes $x + h + k$. 1st, We may have the value of the series by substituting $h + k$ in every term instead of h. 2dly, We may also have its value by substituting $x + k$ in the functions p, q, r, s, &c. for x; that is, instead of p, and q, and r, &c. we must put the values they have when $x + k$ is supposed to be substituted in them instead of x.

By the first-mentioned process we find $f(x + h + k) =$

$$\begin{array}{lllll} u + ph + qh^2 & + rh^3 & + sh^4 & +, \text{\&c.} \\ \quad + pk + 2qhk & + 3rh^2k & + 4sh^3k & +, \text{\&c.} \\ \qquad\qquad + qk^2 & + 3rhk^2 & + 6sh^2k^2 & +, \text{\&c.} \\ & + rk^3 & + 4shk^3 & +, \text{\&c.} \\ & & + sk^4, & +, \text{\&c.} \end{array}$$

And, in employing the second, it must be considered that, when x becomes $x + k$, then

$$u \text{ becomes } u + pk + qk^2 + rk^3 + sk^4 +, \text{\&c.}$$

because k here takes the place of h in the function $f(x + h)$, and its development $u + ph + qh^2 + rh^3 +$, &c.

The supposition that x changes its value to $x + k$, leads to corresponding changes in the functions p, q, r, &c.; so that

$$\begin{array}{ll} p \text{ becomes} & p + p'k + p''k^2 + p'''k^3 +, \text{\&c.} \\ q \;\; . \;\; . \;\; . & q + q'k + q''k^2 + q'''k^3 +, \text{\&c.} \\ r \;\; . \;\; . \;\; . & r + r'k + r''k^2 + r'''k^3 +, \text{\&c.} \\ s \;\; . \;\; . \;\; . & s + s'k + s''k^2 + s'''k^3 +, \text{\&c.} \\ \quad \text{\&c.} & \end{array}$$

Direct Method.

Here p', p'', &c. denote functions of x derived from p, just as p, q, r, &c. are derived from the function u; and a like remark applies to q', q'', &c. also to r', r'', &c. and so on. Substituting now these new values of u, p, q, r, &c. in the series $u + ph + qh^2 + rh^3 + sh^4 +$, &c. we have $f(x + h + k) =$

$$\begin{array}{llllll} u + pk & + qk^2 & + rk^3 & + sk^4 & +, \&c. \\ + ph & + p'hk & + p''hk^2 & + p'''hk^3 & +, \&c. \\ & + qh^2 & + q'h^2k & + q''h^2k^2 & +, \&c. \\ & & + rh^3 & + r'h^3k & +, \&c. \\ & & & + sh^4 & +, \&c. \end{array}$$

By comparing the co-efficients of like powers, or products of powers, of h and k in the two expressions for $f(x + h + k)$, it appears that, to make them identical, we must have

$$2q = p',\ 3r = q',\ 4s = r', \text{ and so on.}$$

$$\text{Therefore } q = \frac{p'}{2}, r = \frac{q'}{3}, s = \frac{r'}{4}, \&c.$$

Now, by the definition of a differential, pdx is the differential of u, where p is the co-efficient of h in the series $u + ph + qh^2 +$, &c. Therefore $p = \frac{du}{dx}$. Similarly, $q'dx$ is the differential of q, where q' is the co-efficient of k in the development $q — q'k + q''k^2 +$, &c. Therefore, $q' = \frac{dq}{dx}$; and in like manner, $r' = \frac{dr}{dx}$ and $s' = \frac{ds}{dx}$, and so on; hence

$$p = \frac{dy}{dx},$$

$$q = \tfrac{1}{2}p' = \tfrac{1}{2}\frac{dp}{dx} = \frac{1}{1.2}\,\frac{d^2u}{dx^2},$$

$$r = \tfrac{1}{3}q' = \tfrac{1}{3}\frac{dq}{dx} = \frac{1}{1.2.3}\,\frac{d^3u}{dx^3},$$

$$s = \tfrac{1}{4}r' = \tfrac{1}{4}\frac{dr}{dx} = \frac{1}{1.2.3.4}\,\frac{d^4u}{dx^4},$$

&c.

These values of p, q, r, s, &c. being substituted in the series $u + ph + qh^2 + rh^3 + sh^4 +$, &c. we obtain $f(x + h) =$

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\,\frac{h^2}{1.2} + \frac{d^3u}{dx^3}\,\frac{h^3}{1.2.3} + \frac{d^4u}{dx^4}\,\frac{h^4}{1.2.3.4} +, \&c.$$

where $u = f(x)$; this is Taylor's theorem.

32. We shall now give another investigation of this important formula, which is remarkable for its brevity and simplicity. It rests on the following analytic principle.

If u *be any function whatever of* v + z, *which relation may be expressed thus,* u = f (v+z); *the differential co-efficient of* u, *found on the supposition that* v *is variable and* z *constant, will be the very same as if it were found on the supposition that* z *is variable and* v *constant.*

To exemplify this in particular cases, suppose $u = (v+z)^n$, then, making v variable and z constant, $\frac{du}{dv} = n(v+z)^{n-1}$; and making z variable and v constant, $\frac{du}{dz} = n(v+z)^{n-1}$, the same as before. Again, let $u = a^{v+z} = a^v\ a^z$, then $\frac{du}{dv}$ and $\frac{du}{dz}$ are expressed by the same quantity $\text{l}.a.a^v\ a^z = \text{l}.a.a^{v+z}$.

The truth of the principle is almost self-evident; for if we make $v + z = x$, so that $f(v + z) = f(x)$; then, whether we suppose v to vary and to become $v + h$, while z remains the same, or z to vary and become $z + h$, while v remains constant, the result is the very same, viz.

$$f(v + z + h) = f(x + h);$$

therefore, in the development of $f\,(v + z + h) = f(x + h)$, viz.

$$f(x) + ph + qh^2 + rh^3 +, \&c.$$

in which p, q, &c. are functions of x; that is, of $v + z$, these functions will be the very same, whichever of the two, v and z, has been considered as the variable, the other remaining constant. Now, by the nature of a differential (art. 7), we have

$$p = \frac{d\{f(x)\}}{dx} = \frac{d\{f(v+z)\}}{d(v+z)};$$

and upon the supposition that v is variable and z constant, then

$$p = \frac{d\{f(v+z)\}}{dv};$$

but supposing z variable and v constant,

$$p = \frac{d\{f(v+z)\}}{dz};$$

$$\text{therefore } \frac{d\{f(v+z)\}}{dv} = \frac{d\{f(v+z)\}}{dz};$$

the first side of this equation being the result of the differentiation, supposing v variable, and the second the result, on the hypothesis that z is variable. Since the two expressions $\frac{d\{f(v+z)\}}{dv}$ and $\frac{d\{(v+z)\}}{dz}$ are identical and the same function of $v + z$, we may represent that function by the symbol $\mathrm{F}(v + z)$; then, by reasoning as before, we shall have

$$\frac{d\{\mathrm{F}(v+z)\}}{dv} = \frac{d\{\mathrm{F}(v+z)\}}{dz},$$

$$\text{that is, } \frac{d^2\{f(v+z)\}}{dv^2} = \frac{d^2\{f(v+z)\}}{dz^2}.$$

Thus it appears that the second differential co-efficient of the function $f\,(v + z)$ is the same expression, whether v or z be regarded as the variable; and the reasoning may be extended to the co-efficient of any order.

33. Supposing now $f(x) = u$ to be any function of x, and $f(x + h) = u'$ to be its value when x becomes $x + h$, it has been proved (art. 29, 30), that the expansion of u is

$$u' = u + ph + qh^2 + rh^3 + sh^4;$$

and here p, q, r, &c. are functions of x, into which x does not at all enter; while, on the other hand, h is entirely independent of x. From the identity of the function u' and its expansion, their differentials, taken on the same hypothesis, must be equal, whichever of the quantities x and h be regarded as the variable. Supposing, first, x variable and h constant, we have

$$\frac{du'}{dx} = \frac{du}{dx} + \frac{dp}{dx}h + \frac{dq}{dx}h^2 + \frac{dr}{dx}h^3 + \frac{ds}{dx}h^4 +, \&c.$$

and next, supposing h to be variable and x constant,

$$\frac{du}{dh} = ph + 2qh + 3rh^2 + 4sh^3 +, \&c.$$

Now it has been shown in last article that $\frac{du'}{dx} = \frac{du'}{dh}$; therefore the series which are their expansions must be identical; and hence the terms independent of h must be equal, also the co-efficients of the same power of h, so that

$$p = \frac{du}{dx},\quad 2q = \frac{dp}{dx},\quad 3r = \frac{dq}{dx},\quad 4s = \frac{dr}{dx}, \&c.;$$

Direct Method.

and since $p = \frac{du}{dx}$, therefore $q = \frac{1}{2}\frac{dp}{dx} = \frac{1}{2}\frac{d^2u}{dx^2}$, and $r = \frac{1}{3}\frac{dq}{dx} = \frac{1}{2.3}\frac{d^3u}{dx^3}$; also $s = \frac{1}{4}\frac{dr}{dx} = \frac{1}{2.3.4}\frac{d^4u}{dx^4}$, &c.; and, on the whole, $f(x+h) =$

$$u' = u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{2} + \frac{d^3u}{dx^3}\frac{h^3}{2.3} + \frac{d^4u}{dx^4}\frac{h^4}{2.3.4} +, \&c.$$

From this formula it appears, that if h be the increment of the variable x; the whole increment of u, any function of x, is

$$u' - u = \frac{du}{dx}\frac{h}{1} + \frac{d^2u}{dx^2}\frac{h^2}{1.2} + \frac{d^3u}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

a series composed of the successive differential co-efficients of the function, each multiplied by an integer power of h, and divided by the products 1, 1 . 2, 1 . 2 . 3, &c.

Application of Taylor's Theorem to the Development of Functions.

We shall now give some applications of this most important analytic formula to the development of functions.

34. Let the function $f(x)$ be $u = x^n$, so that $f(x+h) = (x+h)^n$. By successive differentiation (art. 13 and 27), $\frac{du}{dx} = nx^{n-1}$, $\frac{d^2u}{dx^2} = n(n-1)x^{n-2}$, $\frac{d^3u}{dx^3} = n(n-1)(n-2)x^{n-3}$, $\frac{d^4u}{dx^4} = n(n-1)(n-2)(n-3)x^{n-4}$, &c.

These differential co-efficients, when substituted in the formula, give

$$(x+h)^n = x^n + nx^{n-1}h + \frac{n(n-1)}{1.2}x^{n-2}h^2 + \frac{n(n-1)(n-2)}{1.2.3}x^{n-3}h^3 +, \&c.$$

This is the well-known binomial theorem (ALGEBRA, art. 160).

35. Next, let $f(x)$ be $u = a^x$, a variable power of the constant quantity a. Then, putting

$$\mathrm{A} = (a-1) - \tfrac{1}{2}(a-1)^2 + \tfrac{1}{3}(a-1)^3 - \tfrac{1}{4}(a-1)^4 +, \&c.$$

By article 19, $\frac{du}{dx} = \mathrm{A}a^x$, $\frac{d^2u}{dx^2} = \mathrm{A}^2 a^x$, $\frac{d^3u}{dx^3} = \mathrm{A}^3 a^x$,

$$\frac{d^4u}{dx^4} = \mathrm{A}^4 a^x, \&c.$$

Remarking now that $f(x+h) = a^{x+h} = a^x\, a^h$, we have

$$a^x a^h = a^x\left\{1 + \mathrm{A}h + \frac{\mathrm{A}^2h^2}{1.2} + \frac{\mathrm{A}^3h^3}{1.2.3} + \frac{\mathrm{A}^4h^4}{1.2.3.4} +, \&c.\right\};$$

and dividing both sides by a^x, and changing h into x,

$$a^x = 1 + \mathrm{A}x + \frac{\mathrm{A}^2x^2}{1.2} + \frac{\mathrm{A}^3x^3}{1.2.3} + \frac{\mathrm{A}^4x^4}{1.2.3.4} +, \&c.$$

If we suppose $x = 1$, then,

$$a = 1 + \mathrm{A} + \frac{\mathrm{A}^2}{1.2} + \frac{\mathrm{A}^3}{1.2.3} + \frac{\mathrm{A}^4}{1.2.3.4} +, \&c.$$

and if we make $x = \frac{1}{\mathrm{A}}$, we have

$$a^{\frac{1}{\mathrm{A}}} = 1 + 1 + \frac{1}{1.2} + \frac{1}{1.2.3} + \frac{1}{1.2.3.4} +, \&c.$$

Hence it appears that $a^{\frac{1}{\mathrm{A}}}$ is a constant number, which is the sum of this series. By taking the sum of a sufficient number of its terms, we find

$$a^{\frac{1}{\mathrm{A}}} = 2{\cdot}718281828459.$$

Let this number, which will frequently recur, be denoted by the letter e, and we have

$a^{\frac{1}{\mathrm{A}}} = c$, and $a = e^{\mathrm{A}}$ and

$$e^{\mathrm{A}x} = a^x = 1 + \mathrm{A}x + \frac{\mathrm{A}^2x^2}{1.2} + \frac{\mathrm{A}^3x^3}{1.2.3} + \frac{\mathrm{A}^4x^4}{1.2.3.4} +, \&c.;$$

and making $y = \mathrm{A}x$, so that y may be any number,

$$e^y = 1 + y + \frac{y^2}{1.2} + \frac{y^3}{1.2.3} + \frac{y^4}{1.2.3.4} +, \&c.$$

This formula expresses a remarkable property of the number e.

36. Let the function $f(x)$ be $u = \log x$ to base a, then, by article 20,

$$\frac{du}{dx} = \frac{1}{\mathrm{A}x},\ \frac{d^2u}{dx^2} = \frac{-1}{\mathrm{A}x^2},\ \frac{d^3u}{dx^3} = \frac{1.2}{\mathrm{A}x^3}, \&c.$$

$$\frac{d^4u}{dx^4} = -\frac{1.2.3}{\mathrm{A}x^4},\ \frac{d^5u}{dx^5} = \frac{1.2.3.4.5}{\mathrm{A}x^5}; \&c.$$

Hence, by the theorem, $f(x+h) = \log(x+h) = \log x + \frac{1}{\mathrm{A}}\left\{\frac{h}{x} - \frac{h^2}{2x^2} + \frac{h^3}{3x^3} - \frac{h^4}{4x^4} + \frac{h^5}{5x^5} -, \&c.\right\}$.

Make $x = 1$, and observe that $\log 1 = 0$, and change h into x, and we have

$$\log(1+x) = \frac{1}{\mathrm{A}}\left\{x - \tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 +, \&c.\right\}$$

This is the logarithm of $1+x$ in the system whose base is a.

In the preceding article we found that $a = e^{\mathrm{A}}$, hence, from the theory of logarithms (ALGEBRA, sect. xix.), A is the logarithm of a to the base e. Now

$$\mathrm{A} = a - 1 - \tfrac{1}{2}(a-1)^2 + \tfrac{1}{3}(a-1)^3 - \tfrac{1}{4}(a-1)^4, +, \&c.$$

Therefore, in the system whose base is e,

$$\log a = a - 1 - \tfrac{1}{2}(a-1)^2 + \tfrac{1}{3}(a-1)^3 - \tfrac{1}{4}(a-1)^4;$$

and hence, putting $1+x$ for a, and x for $a-1$, in that system,

$$\log(1+x) = x - \tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 +, \&c.$$

Now we found that in the system whose base is a,

$$\log(1+x) = \frac{1}{\mathrm{A}}\{x - \tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 +, \&c.\}$$

By comparing these two expressions for $\log(1+x)$, it appears that in the system whose base is e, the constant quantity A, which is

$$e - 1 - \tfrac{1}{2}(e-1)^2 + \tfrac{1}{3}(e-1)^3 - \tfrac{1}{4}(e-1)^4 +, \&c.$$

is equal to unity. Logarithms computed according to this system are the same as those first given to the world by Napier, the celebrated inventor of logarithms, who was, however, led to them by a very different path from that here followed. It so happens that the same logarithms express hyperbolic areas, and hence they were called *hyperbolic* logarithms, a distinction quite improper, because hyperbolic areas may be expressed by logarithms of any system. Accordingly, it is now common to denominate them, in honour of the inventor, *Napierian* logarithms. In speaking of these, then, it must be understood that their base is $e = 2{\cdot}718281828459$, &c.; and remembering that the letter l prefixed to any expression of a function means *Napier's logarithm* of that function (art. 19).

$$\mathrm{l.}\,(1+x) = x - \tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 -, \tfrac{1}{4}x^4 +, \&c.$$

and since A = Nap. log a (see last article), therefore in the system whose base is a,

$$\log(1+x) = \frac{1}{\mathrm{l.}\,a}\{x - \tfrac{1}{2}x^2 + \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 +, \&c.\}$$

Direct Method.

The constant multiplier $\frac{1}{\text{l. }a}$, called the *modulus* of the system, is, for Briggs's logarithms,

$$\frac{1}{\text{l. }(10)} = \cdot 4342944819033 \text{ —, and its reciprocal,}$$

$$\text{l. }(10) = 2\cdot 302585092994.$$

37. Let the function be $fx = u = \sin x$, then

$$\frac{du}{dx} = +\cos x, \frac{d^2u}{dx^2} = -\sin x, \frac{d^3u}{dx^3} = -\cos x,$$

$$\frac{d^4u}{dx^4} = +\sin x, \frac{d^5u}{dx^5} = +\cos x, \text{ \&c.}$$

These values of the differential co-efficients being substituted in the theorem, it gives $f(x+h) = \sin(x+h)$

$$= \sin x + \cos x \frac{h}{1} - \sin x \frac{h^2}{1.2} - \cos x \frac{h^3}{1.2.3} + \sin x \frac{h^4}{1.2.3.4} +, \text{ \&c.}$$

$$= \begin{cases} \sin x \left(1 - \frac{h^2}{2} + \frac{h^4}{2.3.4} - \frac{h^6}{2.3.4.5.6} +, \text{ \&c.}\right) \\ + \cos x \left(h - \frac{h^3}{2.3} + \frac{h^5}{2.3.4.5} - \frac{h^7}{2.3.4.5.6.7} +, \text{ \&c.}\right) \end{cases}$$

Let the function be $fx = u = \cos x$, then

$$\frac{du}{dx} = -\sin x, \frac{d^2u}{dx^2} = -\cos x, \frac{d^3u}{dx^3} = \sin x,$$

$$\frac{d^4u}{du^4} = \cos x, \frac{d^5u}{dx^5} = -\sin x, \text{ \&c.}$$

and by substituting in the formula $f(x+h) = \cos(x+h)$

$$= \cos x - \sin x \frac{h}{1} - \cos x \frac{h^2}{2} + \sin x \frac{h^3}{2.3} + \cos x \frac{h^4}{2.3.4} -, \text{ \&c.}$$

$$= \begin{cases} \cos x \left(1 - \frac{h^2}{2} + \frac{h^4}{2.3.4} - \frac{h^6}{2.3.4.5.6} +, \text{ \&c.}\right) \\ - \sin x \left(h - \frac{h^3}{2.3} + \frac{h^5}{2.3.4.5} - \frac{h^7}{2.3.4.5.6.7} +, \text{ \&c.}\right) \end{cases}$$

$$\text{Put } P = 1 - \frac{h^2}{2} + \frac{h^4}{2.3.4} - \frac{h^6}{2.3.4.5.6} +, \text{ \&c.}$$

$$Q = h - \frac{h^3}{2\cdot 3} + \frac{h^5}{2.3.4.5} - \frac{h^7}{2.3.4.5.6.7} +, \text{ \&c.}$$

Then $\sin(x+h) = P \sin x + Q \cos x$,
$\cos(x+h) = P \cos x - Q \sin x$.

Hence, by eliminating Q and P in succession,
$\sin(x+h) \sin x + \cos(x+h) \cos x = P$,
$\sin(x+h) \cos x - \cos(x+h) \sin x = Q$.

Therefore (Algebra, 239), $\cos h = P$, $\sin h = Q$; and exchanging h for x,

$$\cos x = 1 - \frac{x^2}{2} + \frac{x^4}{2.3.4} - \frac{x^6}{2.3.4.5.6} +, \text{ \&c.}$$

$$\sin x = x - \frac{x^3}{2.3} + \frac{x^5}{2.3.4.5} - \frac{x^7}{2.3.4.5.6.7} +, \text{ \&c.}$$

The same results might have been obtained easier by making $x = 0$ in the series for $\sin(x+h)$ and $\cos.(x+h)$.

38. Let the function be the arc whose tangent is x, that is, $u = \tan^{-1} x$;

$$\text{then } du = \frac{dx}{1+x^2} = dx \cos^2 u \text{ (art. 23),}$$

$$\text{and } \frac{du}{dx} = \cos u \cos u.$$

The succeeding differential co-efficients will be found by formulæ (1) and (2) of article 26.

$$\text{By (1) } \frac{d^2u}{dx^2} = -\sin 2u \cos^2 u,$$

$$\text{By (2) } \frac{d^3u}{dx^3} = -2 \cos 3u \cos^3 u,$$

$$\text{By (1) } \frac{d^4u}{dx^4} = 2.3 \sin 4u \cos^4 u,$$

$$\text{By (2) } \frac{d^5u}{dx^5} = 2.3.4 \cos 5u \cos^5 u,$$

$$\text{By (1) } \frac{d^6u}{dx^6} = 2.3.4.5 \sin 6u \cos^6 u,$$

$$\text{By (2) } \frac{d^7u}{dx^7} = -2.3.4.5.6 \cos 7u \cos^7 u, \text{ \&c.}$$

Hence, if we put $\tan u = x$, and $\tan u' = x+h$, we deduce from Taylor's theorem this very general and remarkable formula:

$$u' = u + \cos u \cos u . \frac{h}{1} - \sin 2u \cos^2 u \frac{h^2}{2} - \cos 3u \cos^3 u \frac{h^3}{3}$$

$$+ \sin 4u \cos^4 \frac{h^4}{4} + \cos 5u \cos^5 u \frac{h^5}{5}$$

$$- \sin 6u \cos^6 u \frac{h^6}{6} -, \text{ \&c.}$$

If the arc u be supposed $= 0$, then $\sin u$, $\sin 2u$, &c. are each 0, and the powers of $\cos u$ each $= 1$, and the formula becomes

$$u = \tan u - \frac{1}{3} \tan^3 u + \frac{1}{5} \tan^5 u - \frac{1}{7} \tan^7 u +, \text{ \&c.}$$

a formula due to James Gregory. We have found this series in a very different way (Algebra, art. 270), and have there applied it to the determination of the ratio of the diameter to the circumference. It will be therefore sufficient to state the result here. Let π denote half the circumference of a circle, of which the rad. $= 1$, then

$$\pi = 3\cdot 141592653590 \text{ —.}$$

Maclaurin's Theorem.

39. There is a general formula nearly related to that of Taylor, and indeed an easy deduction from it, commonly called *Maclaurin's Theorem.* It is given at page 610 of the second volume of his fluxions (printed in 1742); but it is proper to say, that the same formula, in substance, was given in 1717 by Stirling, in his *Lineæ Tertii Ordines Neutonianæ*, p. 32.

We have found that $f(x) = u$ being any function of a variable x,

$$f(x+h) = u + \frac{du}{dx} h + \frac{d^2u}{dx^2} \frac{h^2}{2} + \frac{d^3u}{dx^3} \frac{h^3}{2.3} + \frac{d^4u}{dx^4} \frac{h^4}{2.3.4} +, \text{ \&c.}$$

Suppose now that $x = 0$, and that by making this assumption

$f(x) = u$ becomes U,
also that $\frac{du}{dx}$ becomes U',
$\frac{d^2u}{dx^2}$ .... U'',
$\frac{d^3u}{dx^3}$ .... U''',
&c.

Then Taylor's theorem becomes

$$f(h) = U + U'h + U'' \frac{h^2}{1.2} + U''' \frac{h^3}{1.2.3} +, \text{ \&c.}$$

or, changing h into x,

$$f(x) = U + U'x + U'' \frac{x^2}{1.2} + U''' \frac{x^3}{1.2.3} +, \text{ \&c.}$$

From this it appears, that provided u be such a function of x as admits of being expanded into a series of the form

$$u = A + Bx + Cx^2 + Dx^3 +, \text{ \&c.}$$

where A, B, C, D, &c. are constant quantities, then, U being the value of u when $x = 0$, and U', U'', U''', &c. being the values of the differential co-efficients $\frac{du}{dx}, \frac{d^2u}{dx^2}, \frac{d^3u}{dx^3}$, &c. found on that hypothesis, we have

$$A = U, B = U', C = U'', D = U''', \text{\&c.}$$

and consequently,

$$u = U + U'x + U''\frac{x^2}{2} + U'''\frac{x^3}{2 . 3} +, \text{\&c.}$$

This is Maclaurin's theorem, of which we shall now give some applications.

40. Let $u = (a + x)^n$. The expansion of this expression has the requisite form; then $\frac{du}{dx} = n(a + x)^{n-1}$,

$$\frac{d^2u}{dx^2} = n(n-1)(a + x)^{n-2},$$

$$\frac{d^3u}{dx^3} = n(n-1)(n-2)(a + x)^{n-3}, \text{\&c.}$$

The supposition that $x = 0$ makes

$$u = a^n = U, \frac{du}{dx} = na^{n-1} = U', \frac{d^2x}{dx^2} = n(n-1)a^{n-2} = U'',$$

$$\frac{d^3u}{dx^3} = n(n-1)(n-2)a^{n-3} = U''', \text{\&c.}$$

The proper substitutions being made in the general theorem, we have

$$(a + x)^n = a^n + na^{n-1}x + \frac{n(n-1)}{1 . 2}a^{n-2}x^2$$
$$+ \frac{n(n-1)(n-2)}{1 . 2 . 3}a^{n-3}x^3 +, \text{\&c.}$$

41. Let $u = a^x$. This function is also of the kind that admits of expansion by the theorem; the differential coefficients are (art. 19), putting $A = l. a$,

$$\frac{du}{dx} = Aa^x, \quad \frac{d^2u}{dx^2} = A^2a^x, \quad \frac{d^3u}{dx^3} = A^3a^x, \text{\&c.}$$

The supposition that $x = 0$ gives $u = 1$, and

$$\frac{du}{dx} = A, \quad \frac{d^2u}{dx^2} = A^2, \quad \frac{d^3u}{dx^3} = A^3, \text{\&c.}$$

$$\text{Hence } a^x = 1 + Ax + \frac{A^2x^2}{1 . 2} + \frac{A^3x^3}{1 . 2 . 3} +, \text{\&c.}$$

as was found in art. 35.

42. The formula $u = \log x$ does not admit of being expanded into a series of the prescribed form, for in this case $\frac{du}{dx} = \frac{1}{Ax}$; the supposition that $x = 0$ makes u and $\frac{du}{dx}$, as well as all the following differential co-efficients, infinite. The function $u = \log(n + x)$, however, admits of the application of the formula. In this case (art. 20),

$$\frac{du}{dx} = \frac{1}{A(n + x)}, \frac{d^2u}{dx^2} = \frac{-1}{A(n+x)^2}, \frac{d^3u}{dx^3} = \frac{1 . 2}{A(n+x)^3}, \text{\&c.}$$

The assumption that $x = 0$ makes $u = \log n = U$, and

$$\frac{du}{dx} = \frac{1}{An} = U', \frac{d^2u}{dx^2} = -\frac{1}{An^2} = U'', \frac{d^3u}{dx^3} = \frac{1 . 2}{An^3} = U''', \text{\&c.}$$

We have now, by the general formula,

$$\log(n + x) = \log n + \frac{1}{A}\left\{\frac{x}{n} - \frac{x^2}{2n} + \frac{x^3}{3n} -, \text{\&c.}\right\}.$$

By making $n = 1$, and therefore $\log n = 0$, we have the expression for $\log(1 + x)$, as already found.

43. The theorem may be applied to the functions $u = \sin x$, and $u = \cos x$, without the least difficulty. For the first we have

$$U = 0, \quad U' = 1, \quad U'' = 0, \quad U''' = -1, \text{\&c.}$$

$$\text{and } \sin x = x - \frac{x^3}{1 . 2 . 3} + \frac{x^5}{1 . 2 . 3 . 4 . 5} +, \text{\&c.};$$

for the second function

$$U = 1, \quad U' = 0, \quad U'' = -1, \quad U''' = 0, \text{\&c.}$$

$$\cos x = 1 - \frac{x^2}{1 . 2} + \frac{x^4}{1 . 2 . 3 . 4} - \frac{x^6}{1 . 2 . 3 . 4 . 5 . 6} +, \text{\&c.}$$

44. Let u denote the arc whose sine is x; that is, let $u = \sin^{-1} x$. In this case (23),

$$\frac{du}{dx} = (1 - x^2)^{-\frac{1}{2}},$$

$$\frac{d^2u}{dx^2} = x(1 - x^2)^{-\frac{3}{2}},$$

$$\frac{d^3u}{dx^3} = (1 - x^2)^{-\frac{3}{2}} + 3x^2(1 - x)^{-\frac{5}{2}},$$

$$\frac{d^4u}{dx^4} = 3 . 3x(1 - x^2)^{-\frac{5}{2}} + 3 . 5x^3(1 - x^2)^{-\frac{7}{2}},$$

&c.

Making $x = 0$ we get $U = 0$, $U' = 1$, $U'' = 0$, $U''' = 1$, $U^{\text{IV}} = 0$; and, by continuing the process of differentiation, $U^{\text{V}} = 3 . 3$, &c. therefore

$$u = x + \frac{x^3}{1 . 2 . 3} + \frac{3 . 3x^5}{1 . 2 . 3 . 4 . 5} + \frac{3^2 . 5^2x^7}{1 . 2 . 3 . 4 . 5 . 6 . 7} +, \text{\&c.}$$

Cases in which Taylor's Theorem fails.

45. We have seen that Taylor's theorem, viz. $u = f(x)$ being any function of a variable x,

$$f(x + h) = u + \frac{du}{dx}\frac{h}{1} + \frac{d^2u}{dx^2}\frac{h^2}{1 . 2} + \frac{d^3u}{dx^3}\frac{h^3}{1 . 2 . 3} +, \text{\&c.}$$

will always hold true, provided that the variable x be regarded as indeterminate. If however particular values be given to x, there are cases in which the development is of no use, because in these cases it is not applicable to the function.

For example, let $u = b + (x - a)^{\frac{1}{2}}$; in this case,

$$\frac{du}{dx} = \frac{1}{2(x - a)^{\frac{1}{2}}}, \frac{d^2u}{dx^2} = -\frac{1}{4(x - a)^{\frac{3}{2}}}, \text{\&c.}$$

and by the theorem,

$$f(x + h) = b + (x - a + h)^{\frac{1}{2}} = b + (x - a)^{\frac{1}{2}}$$
$$+ \frac{1}{2(x - a)^{\frac{1}{2}}}h - \frac{1}{8(x - a)^{\frac{3}{2}}}h^2 +, \text{\&c.}$$

Now if we give to x any particular value greater than a, the development is perfectly significant, and expresses truly the value of $b + (x - a + h)^{\frac{1}{2}}$. If however we give to x the particular value a, then $x - a = 0$, and the development becomes $b + 0 + \frac{h}{2(0)^{\frac{1}{2}}} - \frac{h^2}{8(0)^{\frac{3}{2}}} +$, &c. from which no conclusion whatever can be drawn, because all the terms having *zero* in the denominator are infinite.

If in the expression $b + (x - a + h)^{\frac{1}{2}}$ we make $x = a$, it becomes $b + h^{\frac{1}{2}}$. This expression has two values, viz. $b + \sqrt{h}$, $b - \sqrt{h}$. The development given by the theorem contains, however, only positive integer powers of h; therefore it can have only a single value; and hence it is impossible that it should express the function in the particular case of $x = a$. In such cases the theorem has been said to *fail*; this however happens not from any imperfection in the theorem, but merely because it is unsuitable to the purpose to which it has been applied; and this want of applicability is indicated by the co-efficients of the powers of h failing to express any thing definite.

46. Again, let the function be $u = \frac{b}{(x - a)^2}$; then

$$\frac{du}{dx} = -\frac{2b}{(x-a)^3}, \frac{d^2u}{dx^2} = \frac{6b}{(x-a)^4}, \text{ \&c.}$$

In this case

$$f(x+h) = \frac{b}{(x-a+h)^2} = \frac{b}{(x-a)^2} - \frac{2b}{(x-a)^3}h$$
$$+ \frac{3b}{(x-a)^4}h^2 -, \text{ \&c.}$$

Here x may have any particular value greater or less than a, and the development will be perfectly significant; if, however, x be equal to a, it becomes

$$\frac{b}{(o)^2} - \frac{2b}{(o)^3}h + \frac{3b}{(o)^4}h^2 -, \text{ \&c.};$$

an expression that has no meaning, because each of the co-efficients of h is infinite.

If we make $x = a$ in $\frac{b}{(x+a+h)^2}$, the function to be expanded, it becomes $\frac{b}{b^2} = bh^{-2}$, an expression in which the exponent of h is negative; therefore this case cannot be included in a formula which contains only positive integers of h, and hence the apparent failure of the theorem.

47. That a general formula should not express all particular cases, was at one time regarded as a kind of paradox in analysis. Lagrange first cleared up this point, and showed, that when by giving particular values to x, the new state of the function contains terms of the form Ph^{-n}, or $Qh^{\frac{m}{n}}$, that is, negative or fractional powers of h, then, from the very nature of the calculus, all the co-efficients in the general development after a certain term will become infinite. On the other hand, when a particular value of x renders the co-efficients infinite, we may conclude that the development in that case ought to contain fractional or negative powers of h. In such particular cases as appear not to admit of expansion by Taylor's theorem, other methods deducible from the calculus are applicable; in general, the ordinary algebraic methods are sufficient.

Differentiation of Equations of two Variables.

48. We have as yet differentiated only equations in which the variables were separated, such as this, $y = a + bx + cx^2$, where y is an implicit function of x. But the equations which chiefly occur in analytical inquiries contain for the most part the two variables combined or mixed together; as in this equation,

$$y^2 - 2mxy + x^2 - a^2 = 0.$$

If we suppose the equation resolved, so that y is expressed in terms of x only, which gives

$$y = mx \pm \sqrt{a^2 + (m^2-1)x^2},$$

the differentials may be found by the rules already explained. In general, however, the variables cannot be so separated, and therefore it is necessary that we be able to determine the differential co-efficients of a function by other means.

49. An equation formed in any way from two independent variable quantities may be represented by the general symbol

$$f(x, y) = 0.$$

The variable y must be expressible in some way by x; therefore we may represent its value, however found, by the equation $y = X$, where X denotes an expression made up of terms containing only x and constant quantities. When this value of y is substituted in the equation, it becomes

$$f(x, X) = 0.$$

This is an identical equation, involving x only, which must hold true whatever value be given to x. Let the expression $f(x, X) = f(x, y)$ be denoted briefly by u. Suppose now x to change its value and become $x + h$; by Taylor's theorem, its new values will be

$$u' = u + \frac{du}{dx}h + \frac{d^2u}{dx^2}h^2 + \frac{d^3u}{dx^3}h^3 +, \text{ \&c.}$$

The equation $f(x, y) = u = 0$ must hold true whatever value be given to x; therefore we must have $u' = 0$, and this requires that the co-efficients of the different powers of the indeterminate quantity h be separately $= 0$ (art. 18), so that from the equation $u = f(x, y) = 0$ there may be derived a series of equations,

$$\frac{du}{dx} = 0, \frac{d^2u}{dx^2} = 0, \frac{d^3u}{dx^3} = 0, \text{ \&c.}$$

which must all hold true at the same time as the original equation.

50. Let us take for example the equation

$$y^2 + x^2 = a^2, \text{ or } y^2 + x^2 - a^2 = 0 \ldots\ldots\ldots (1.)$$

in which a is a constant quantity; in this case,

$$u = y^2 + x^2 - a^2;$$

hence we have by differentiation

$$\frac{du}{dx} = 2y\frac{dy}{dx} + 2x = 0,$$

$$\text{and } \frac{dy}{dx} = -\frac{x}{y} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.).$$

To determine the differential co-efficient of the second order, put $\frac{dy}{dx} = p$, and we have

$$\frac{du}{dx} = 2yp + 2x;$$

as p is a function of x and y, and y is a function of x, therefore p is a function of x. Taking now the differentials, and dividing by dx, the result is

$$\frac{d^2u}{dx^2} = 2\left(y\frac{dp}{dx} + p\frac{dy}{dx} + 1\right) = 0;$$

hence, because $p = \frac{dy}{dx}$, and $\frac{dp}{dx} = \frac{d^2y}{dx^2}$,

$$\frac{d^2u}{dx^2} = 2\left(y\frac{d^2y}{dx^2} + \frac{dy^2}{dx^2} + 1\right) = 0 \ldots\ldots\ldots\ldots\ldots (3.)$$

From this equation we get

$$\frac{d^2y}{dx^2} = -\frac{1}{y}\left(\frac{dy^2}{dx^2} + 1\right),$$

$$\text{or, since } \frac{dy}{dx} = -\frac{x}{y},$$

$$\frac{d^2y}{dx^2} = -\frac{x^2}{y^3} - \frac{1}{y} \ldots\ldots\ldots\ldots\ldots\ldots (4.)$$

To find the differential co-efficient of the third order, we put $\frac{d^2y}{dx^2} = \frac{dp}{dx} = q$; and substituting p for $\frac{dy}{dx}$ in equation (3), it becomes

$$\frac{d^2u}{dx^2} = 2(yq + p^2 + 1) = 0;$$

observing that p and q are functions of x and y, and consequently of x, we may find by differentiation an expression which will involve, besides x and y, these quantities,

$$\frac{dq}{dx}, \frac{dp}{dx} = \frac{d^2y}{dx^2}, q = \frac{d^2y}{dx^2}, p = \frac{py}{dx};$$

and from this equation $\frac{dq}{dx} = \frac{d^3y}{dx^3}$ may be determined, observing that $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$ are expressed by x and y in equations (4) and (2).

51. The preceding analysis gives the following rule for

Direct Method.

determining the differential co-efficients of y, a function of x, when the relation between x and y is expressed by an equation.

Take the differentials of the terms of the equation, considering y as a function of x, and dividing by dx, the result will be an equation which gives the value of $\frac{dy}{dx}$. Again, take the differentials of the terms of this equation, considering y and $\frac{dy}{dx}$ as functions of x, and the result will be an equation involving $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$, which, combined with the former, serves to determine $\frac{d^2y}{dx^2}$. A third equation may be found from this, by taking the differentials, and considering y, $\frac{dy}{dx}$, and $\frac{d^2y}{dx^2}$, as functions of x; and this, combined with the other two, gives $\frac{d^3y}{dx^3}$, and so on to any number of equations.

Let y be such a function of x that

$$y^2 - 2\,mxy + x^2 - a^2 = 0 \ldots\ldots\ldots\ldots\text{(1.)}$$

It is proposed to determine its differential co-efficients.

By a first differentiation

$$(y - mx)\,dy - (my - x)\,dx = 0,$$

$$\text{and } \frac{dy}{dx} = \frac{my - x}{y - mx} \ldots\ldots\ldots\ldots\ldots\ldots\text{(2.)}$$

Again, by differentiating,

$$\frac{d^2y}{dy^2} = \frac{(1 - m^2)x}{(y - mx)^2} \cdot \frac{dy}{dx} - \frac{(1 - m^2)y}{(y - mx)^2} \ldots\ldots\text{(3.)}$$

and, substituting for $\frac{dy}{dx}$ its value,

$$\frac{d^2y}{dx^2} = -(1 - m^2)\,\frac{y^2 - 2\,mxy + x^2}{(y - mx)^3} = \frac{-(1 - m^2)a^2}{(y - mx)^3}\text{(4.)}$$

If we take the differentials of both sides of equation (3), and consider $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, as functions of x, we shall obtain

$$\frac{d^3y}{dx^3} = \mathrm{P}\,\frac{d^2y}{dx^2} + \mathrm{Q}\,\frac{dy}{dx} + \mathrm{R} \ldots\ldots\ldots\ldots\ldots\text{(5.)}$$

Here P, Q, R, denote expressions composed of y and x. By substituting for $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$ their values as given by equations (4) and (2), there will be obtained the value of $\frac{d^3y}{dx^3}$, in terms of x and y.

52. The equations which may be deduced by differentiation from a proposed equation are called *fluxional* or *differential* equations, and the equation from which they have been deduced is called the *primitive* equation. The equation which gives the value of $\frac{dy}{dx}$ is said to be of the *first order*, and that which involves $\frac{d^2y}{dx^2}$ is of the *second order*, and so on for the higher orders.

Thus, the primitive equation being

$$y^2 - 2mxy + x^2 - a^2 = 0,$$

we have found, for the differential equation of the first order,

$$\frac{dy}{dx} - \frac{my - x}{y - mx} = 0\,;$$

and that of the second order,

$$\frac{d^2y}{dx^2} - \frac{(1 - m^2)}{y - mx}\,\frac{dy}{dx} + \frac{(1 - m^2)y}{(y - mx)^2} = 0,$$

equivalent to $\frac{d^2y}{dx^2} + (1 - m^2)\,\frac{y^2 - 2mxy + x^2}{(y - mx)^3} = 0.$

53. Differential equations of all orders hold true simultaneously with the primitive from which they have been derived, therefore any combination of them will also hold true; and whatever number of values the function y has (in the preceding example it has two), the differential co-efficients into which y enters will have the same number.

It has appeared (art 15) that in functions of a certain form the constants they contain vanish from their differentials. A like remark applies to differential equations. Thus, if $y^2 = ax + b$ be a primitive equation, in which a and b are constants, the differential equation is $2ydy = adx$; and this belongs to every particular equation which can be formed from the primitive, by giving all possible values to b. The constant a may also be made to disappear by putting the equation under this form,

$$\frac{y^2}{x} = a + \frac{b}{x}\,;$$

for this by differentiation gives

$$\frac{2xydy - y^2dx}{x^2} = \frac{-bdx}{x^2},$$

$$\text{and } 2xydy - (y^2 - b)\,dx = 0\,;\text{ or } \frac{dy}{dx} = \frac{y^2 - b}{2xy}.$$

This equation expresses a relation which subsists between the quantities x, y, $\frac{dy}{dx}$, independently of any particular value of the constant a.

The very same equation will be obtained by eliminating, by the ordinary process (ALGEBRA, sect. 7), a from the two equations

$$y^2 = ax + b,\ 2ydy = adx.$$

If the constant quantity which is eliminated is not of the first degree in the proposed equation, the result will contain powers of the co-efficient $\frac{dy}{dx}$ higher than the first. For example, let the equation be

$$y^2 - 2ay + x^2 = a^2\,;$$

then, by differentiating,

$$2ydy - ady + xdx = 0,$$

$$\text{hence } a = \frac{ydy + xdx}{dy}.$$

This value of a being substituted in the proposed equation, we obtain, after due reduction,

$$(x^2 - 2y^2)\,\frac{dy^2}{dx^2} - 4xy\frac{dy}{dx} - x^2 = 0\,;$$

an equation that expresses a relation between x, y, $\frac{dy}{dx}$, which is independent of any particular value of a.

By resolving the equation in respect of a, we find

$$a = -y \pm \sqrt{2y^2 + x^2}\,;$$

and hence, the constant a forming a term by itself, it disappears by differentiation, and we have

$$dy \pm \frac{2ydy + xdx}{\sqrt{2y^2 + x^2}} = 0,$$

an equation which, being from the radical sign, will be identical with the former.

54. Any number of constants whatever may be made to disappear by repeating the process of differentiation as often as there are quantities to be eliminated; for example, let the equation be $y^2 = m\,(a^2 - x^2)$; by a first differentiation $y\,\frac{dy}{dx} = -mx$; taking the differentials a se-

cond time, we get $y\frac{d^2y}{dx^2}+\frac{dy^2}{dx^2}=-m$. This value of $-m$ being substituted in the former equation, it becomes

$$y\frac{dy}{dx}-x\frac{dy^2}{dx^2}-xy\frac{d^2y}{dx^2}=0,$$

a result which is independent of both a and m.

Of Vanishing Fractions.

55. When the numerator and denominator of a fraction are such functions that, by giving a particular value to their variable, they both become $=0$ at the same time, the fraction is then called a *vanishing* fraction. The fraction $\frac{x^2-a^2}{x-a}$ is of this kind; for when $x=a$, the numerator and denominator both vanish, and the fraction takes the form $\frac{0}{0}$, from which we can draw no conclusion as to its true value, although it be evident that the fraction has then a determinate value; for

$$\frac{x^2-a^2}{x-a}=\frac{(x+a)(x-a)}{x-a}=x+a;$$

and when $x=a$, its true value is as $a+a=2a$.

It appears that the above fraction has taken the peculiar form $\frac{0}{0}$ when $x=a$, from the circumstance of its having the factor $x-a$ in the numerator and denominator. The same is true of this other fraction,

$$\frac{x^3-x^2a-xa^2+a^3}{ax-a^2},$$

which takes form $\frac{0}{0}$ when $x=a$. The numerator and denominator have a common divisor, $x-a$; when freed from this, it becomes $\frac{x^2-a^2}{a}$; when $x=a$, this fraction becomes $\frac{0}{a}$, which is truly $=0$. Again, this fraction $\frac{ax-a^2}{x^2-2ax+a^2}$, which has the same property when $x=a$, by reason of the common factor $x-a$, when freed from the factor is $\frac{a}{x-a}$. Thus when $x=a$ becomes $\frac{a}{0}$, that is, the value is infinite. In these cases the common factor is obvious; but it is not so always. Take this as an example, $\frac{1-\sin x+\cos x}{\sin x+\cos x-1}$; when x is a quadrant, or $=\frac{1}{2}\pi$, this fraction becomes $\frac{0}{0}$. For its true value in this case, see ex. 4 of art. 57.

56. When the terms of the fraction are algebraic functions, their greatest common measure may be found by an elementary operation in ALGEBRA (art. 20), and the fraction disengaged from it by division. A more simple and general solution may, however, be obtained from the differential calculus.

Let $\frac{P}{Q}$ denote a fraction, the terms of which are functions of x that vanish when $x=a$, some given quantity. Suppose now that x becomes $x+h$, then, by Taylor's theorem, the fraction will become

$$\frac{P+\frac{dP}{dx}h+\frac{d^2P}{dx^2}\frac{h^2}{1\,.\,2}+\frac{d^3P}{dx^3}\frac{h^3}{1\,.\,2\,.\,3}+,\ \&c.}{Q+\frac{dQ}{dx}h+\frac{d^2Q}{dx^2}\frac{h^2}{1\,.\,2}+\frac{d^3Q}{dx^3}\frac{h^3}{1\,.\,2\,.\,3}+,\ \&c.}.$$

By hypothesis, when $x=a$, then P and Q both vanish; therefore, leaving them out of the expression, and putting P′, P″, P‴, &c. to denote the differential co-efficients of P in the numerator, and Q′, Q″, Q‴, &c. those of Q in the denominator, and dividing the terms by h, the fraction will be expressed by

$$\frac{P'+\frac{1}{2}P''h+\frac{1}{6}P'''h^2+,\ \&c.}{Q'+\frac{1}{2}Q\,h+\frac{1}{6}Q'''h^2+,\ \&c.}.$$

When $h=0$, this expression becomes $\frac{P'}{Q'}$; and when a is put in this fraction instead of x, the result will be the true value of $\frac{P}{Q}$; for it is manifestly the same thing to suppose, first, that x becomes $x+h$, and then that $x=a$ and $h=0$, as to suppose at once that $x=a$.

If it happen that one of the two quantities, P′, Q′, becomes $=0$ when a is substituted instead of x, then the fraction $\frac{P}{Q}$ will be $=0$, or infinite, according as the vanishing quantity is the numerator or denominator; if both become $=0$ at once, then, leaving them out, the expression becomes, by reduction,

$$\frac{P''+\frac{1}{3}P'''h+,\ \&c.}{Q''+\frac{1}{3}Q'''h+,\ \&c.};$$

and making $h=0$, it become $\frac{P''}{Q''}$, which, putting a instead of x, will be the value of the fraction $\frac{P}{Q}$, and so on.

57. Hence we have this rule: To find the fraction $\frac{P}{Q}$ in the particular case of $x=a$, supposing that P and Q are both reduced to 0 by this supposition. Divide the differential co-efficient of the numerator by that of the denominator; let the result be $\frac{P'}{Q'}$, in which make $x=a$; then, if this expression does not become $\frac{0}{0}$, it is the value sought; but if it takes the form $\frac{0}{0}$, treat the fraction $\frac{P'}{Q'}$ in all respects like the original fraction, and deduce from it a new fraction $\frac{P''}{Q''}$, and proceed in this way until an expression be found which does not become $\frac{0}{0}$ when a is put for x; and the first expression that is found having this property is the value sought.

Ex. 1. The sum of the geometrical series

$$1+x+x^2+x^3\ldots+x^{n-1}\text{ to }n\text{ terms}$$

is $\frac{x^n-1}{x-1}$. Find its value when $x=1$.

In this case, $P=x^n-1$, $Q=x-1$; hence we deduce $\frac{dP}{dx}=nx^{n-1}=P'$; $\frac{dQ}{dx}=1=Q$, $\frac{P'}{Q'}=nx^{n-1}$; when $x=1$, the fraction $\frac{P'}{Q'}=n$, the value of the sum of the series, as is manifest.

Ex. 2. Let the fraction be $\frac{ax^2+ac^2-2acx}{bx^2-2bcx+bc^2}=\frac{P}{Q}$, which becomes $\frac{0}{0}$ when $x=c$, to find its value. In this case $\frac{dP}{dx}=2ax-2ac=P'$; $\frac{dQ}{dx}=2bx-2bc=Q'$;

$$\frac{P'}{Q'} = \frac{2ax - 2ac}{2bx - 2bc} = \frac{ax - ac}{bx - bc}.$$

Making $x = c$, this fraction becomes $\frac{0}{0}$, therefore, proceeding as before,

$$\frac{d^2P}{dx^2} = 2a = P'', \; \frac{d^2Q}{dx^2} = 2b = Q'', \; \frac{P''}{Q''} = \frac{a}{b};$$

hence it appears that when $x = c$, the value of the fraction is $\frac{a}{b}$.

Ex. 3. The fraction $\frac{a^x - b^x}{x}$ becomes $\frac{0}{0}$ when $x = 0$. Find its value then. In this case,

$$\frac{dP}{dx} = \text{l.}\,(a)\, a^x - \text{l.}\,(b)\, b^x = P'; \; \frac{dQ}{dx} = 1 = Q'.$$

When $x = 0$, $\frac{P'}{Q'}$ becomes $\text{l.}\,(a) - \text{l.}\,(b) = \text{l.}\,\frac{a}{b}$, the value required.

Ex. 4. Let the fraction be $\frac{1 - \sin x + \cos x}{\sin x + \cos x - 1}$, which becomes $\frac{0}{0}$ when $x = \frac{1}{2}\pi$. Here

$$\frac{dP}{dx} = -\cos x - \sin x = P'; \; \frac{dQ}{dx} = \cos x - \sin x = Q';$$

$$\frac{P'}{Q'} = \frac{-\cos x - \sin x}{\cos x - \sin x}.$$

When $x = \frac{1}{2}\pi$, a quadrant, then $\cos x = 0$, and $\sin x = 1$; the value of the proposed fraction is therefore $\frac{-1}{-1} = 1$.

Ex. 5. Let the fraction be $\frac{a^{a-n} - x^{x-n}}{a - x}$; to find its value when $x = a$. In this case $P = a^{a-n} - x^{x-n}$, $Q = a - x$.

$$P' = \frac{dP}{dx} = -x^{x-n}\left\{\text{l.}\,x + \frac{x-n}{x}\right\};$$

$$Q' = \frac{dQ}{dx} = -1,$$

$$\frac{P'}{Q'} = x^{x-n}\left\{\text{l.}\,x + \frac{x-n}{x}\right\}:$$

making $x = a$, we have $a^{a-n}\left\{\text{l.}\,a + \frac{a-n}{a}\right\}$ for the value required.

58. The rule of last article will not apply when Taylor's theorem fails to give the developments of the functions P, Q, in the case when $x = a$. When this happens, we may substitute $a + h$ instead of x in the fraction $\frac{P}{Q}$, and expand the numerator and denominator into ascending series, which proceed by the powers of h; we shall then have

$$\frac{Ah^\alpha + Bh^\beta +, \&c.}{A'h^{\alpha'} + B'h^{\beta'} +, \&c.}$$

instead of the proposed fraction. If in this result we suppose $h = 0$, we shall have the value of the fraction $\frac{P}{Q}$ when $x = a$. Now there are here three cases; viz. $\alpha > \alpha'$, $\alpha = \alpha'$, and $\alpha < \alpha'$. In the first case, we may write the expression thus:

$$\frac{Ah^{\alpha - \alpha'} + Bh^{\beta - \alpha} +, \&c.}{A' + B'h^{\beta - \alpha'} +, \&c.};$$

Under this form, it is manifest that as long as α is greater than α', the supposition of $h = 0$ will make the fraction equal to nothing, and that it will become $\frac{A}{A'}$ when $\alpha = \alpha'$; but when $\alpha < \alpha'$, we write the expression thus:

$$\frac{A + Bh^{\beta - \alpha} +, \&c.}{A'h^{\alpha' - \alpha} + B'h^{\beta' - \alpha} +, \&c.};$$

and by the supposition of $h = 0$, this result becomes infinite. In all cases the true value depends on the first term alone of each series.

59. The following rule extends to all fractions which can occur under the indeterminate form $\frac{0}{0}$.

Take the first term of each of the series which express the development of the numerator and denominator when x = a + h; *reduce the resulting fraction to its most simple form, and then make* h = 0.

The fraction $\frac{(x^2 - a^2)^{\frac{3}{2}}}{(x - a)^{\frac{3}{2}}}$, whose value cannot be found by differentiation, when $x = a$ becomes by this method

$$\frac{(2ah + h^2)^{\frac{3}{2}}}{h^{\frac{3}{2}}} = (2a + h)^{\frac{3}{2}},$$

when x is changed into $x + h$; making now $h = 0$, we have its true value $(2a)^{\frac{3}{2}}$.

This last rule will sometimes be preferable to the former, by differentiation, even when that process is applicable. For example, four successive differentiations must be performed on the numerator and denominator of this fraction,

$$\frac{x^3 + 4ax^2 + 7a^2 x - 2a^3 - 2a^2 \sqrt{2ax - a^2}}{x^2 - 2ax - a^2 + 2a \sqrt{2ax - x^2}},$$

in order to find its true value when $x = a$; by writing $a + h$ instead of x, it becomes

$$\frac{2a^3 - 2a^2 h - ah^2 + h^3 - 2a^2 \sqrt{a^2 + 2al}}{-2a^2 + h^2 + 2a \sqrt{a^2 - h^2}}$$

and reducing the radical quantities into series, we have

$$\sqrt{a^2 + 2ah} = a + h - \frac{h^2}{2a} + \frac{h^3}{2a^2}, - \frac{5h^4}{8a^3}, +, \&c.$$

$$\sqrt{a^2 - h^2} = a - \frac{h^2}{2a} - \frac{h^4}{8a^3} -, \&c.$$

By substituting these series in the fraction, and putting $h = 0$, we obtain $-5a$ for the value sought.

Of the greatest and least Values of a Function.

60. In supposing that a function changes its value, we may assume that the variable increases continually from 0 to infinity, either positively or negatively. To get distinct notions, it may be convenient to suppose that the variable increases or decreases by successive equal differences. The function however may not increase or decrease continually along with its variable. It may first increase to a certain magnitude, and afterwards decrease; or it may decrease and afterwards increase; or it may alternately increase and decrease several times. We may represent the variable x by the abscissa of a curve, and the function y by the corresponding ordinate. The curve, from

its nature, may recede continually from its axis, like the parabola and hyperbola; or it may first recede from and afterwards approach to the axis, like the circle and ellipse; or it may be sinuous, alternately approaching and receding.

When a variable function, by a continual change in its magnitude, first increases and afterwards decreases, there will be one value of the function which will be greater than those which immediately preceded it, and also greater than those which immediately follow it. In this state the value of the function is the greatest possible, at least within certain limits on each side of that extreme value; and then it is said to be a *maximum*. On the other hand, if a function, by a continual change in its value, first decreases, until it be reduced to a certain magnitude, and afterwards increases, it is said to be a *minimum*, when it is just changing from the state of a decreasing to that of an increasing quantity.

A variable function may have several values, each of which will be a *maximum* or *minimum*, according to the definition. *The essential character of a maximum consists in its being greater than the values which preceded and which follow it; and that of a minimum in being less than the preceding and following values.* So that as many changes as there may be from increase to decrease, or the contrary, so many *maxima* and *minima* there will be.

61. Before proceeding farther, it will be convenient to establish this principle. In a series of the form

$$ph + qh^2 + rh^3 + sh^4 +, \&c.$$

in which h is indeterminate, and independent of p, q, r, &c. such a value may be given to h, that any term shall exceed the amount of all that follow it. For, putting the series under this form,

$$h\,(p + qh + rh^2 + sh^3 +, \&c.);$$

by supposing h to decrease, $qh + rh^2 + sh^3 +$, &c. may become less than any assignable quantity, and therefore less than p; consequently, $qh^2 + rh^3 + sh^4 +$, &c. may be less than ph, in any ratio of inequality. In the same way it will appear that $rh + sh^2 +$, &c. may be less than q, and $rh^3 + sh^4 +$, &c. less than qh^2, and so on. Hence it follows, that in the series $ph + qh^2 + rh^3 + sh^4 +$, &c. h may have such a value that the amount of all the terms beginning with any assigned term shall have the sign of that term, $+$ if it be $+$, and $-$ if it be $-$.

62. Let y denote any function which may become a *maximum* or *minimum* when its variable has attained some particular value; then, if $x - h$ and $x + h$ be substituted successively in the function instead of x, the two results must be both less than the maximum value, and both greater than the minimum value. Denoting now the value of the function which corresponds to $x - h$ by ${}_1y$, and the value which corresponds to $x + h$ by y_1, we have, by Taylor's theorem,

$${}_1y = y - \frac{dy}{dx}h + \frac{d^2y}{dx^2}\frac{h^2}{1.2} - \frac{d^3x}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

$$y_1 = y + \frac{dy}{dx}h + \frac{d^2y}{dx^2}\frac{h^2}{1.2} + \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

Now, it is impossible that ${}_1y$ and y_1 can at the same time be both less or both greater than y, if the co-efficient $\frac{dy}{dx}$ be not $= 0$; for if it have some value different from *zero*, then such a value may be given to h that $\frac{dy}{dx}h$ shall exceed in any given ratio of inequality all the terms which follow it, and one of the two series beginning with $\mp \frac{dy}{dx}h$ will be a positive quantity and the other negative; and if this were true, y would be of an intermediate magnitude between ${}_1y$ and y_1, which cannot be, when it is a *maximum* or *minimum*. Therefore, in order that y may be a *maximum* or *minimum*, we must have $\frac{dy}{dx} = 0$, and then, in the expressions

$${}_1y = y + \frac{d^2y}{dx^2}\frac{h^2}{1.2} - \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

$$y_1 = y + \frac{d^2y}{dx^2}\frac{h^2}{1.2} + \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} +, \&c.$$

such a value may be given to h as shall make ${}_1y$ and y_1 both less than y in the case of a *maximum*, or both greater in that of a *minimum*.

It may, however, happen that the value of x which makes $\frac{d^2y}{dx^2} = 0$ shall also make $\frac{d^2y}{dx^2} = 0$, so that we have

$${}_1y = y - \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} + \frac{d^4y}{dx^4}\frac{h^4}{1.2.3.4} -, \&c.$$

$$y_1 = y + \frac{d^3y}{dx^3}\frac{h^3}{1.2.3} + \frac{d^4y}{dx^4}\frac{h^4}{1.2.3.4} +, \&c.$$

Then the function cannot be a maximum or minimum, unless the same value of x make $\frac{d^3y}{dx^3} = 0$, and give a finite value for $\frac{d^4y}{dx^4}$

63. On the whole, we have this rule, to determine the maximum or minimum value of y, a function of x.

Make the differential co-efficient $\frac{\mathrm{dy}}{\mathrm{dx}} = 0$: *Find the value of* x, *and substitute it in* $\frac{\mathrm{d^2y}}{\mathrm{dx^2}}$; *and if the result be negative, the function is a* maximum; *but if it be positive, the function is a* minimum. *And if it be* $= 0$, *then put* $\frac{\mathrm{d^3y}}{\mathrm{dx^3}} = 0$, *and find* x, *and substitute it in* $\frac{\mathrm{d^4y}}{\mathrm{dx^4}}$, *and draw the same conclusions from the signs as before, and so on.*

The rule for determining a maximum or minimum of a function was first given correctly by Maclaurin, in his FLUXIONS, chap. ix.

64. We shall now apply the theory to the resolution of problems, of which there may be an endless variety, and many highly interesting.

Ex. 1. To determine whether the function $u = 2ax - x^2$ has a *maximum* or *minimum* value.

In this case the differential co-efficient $\frac{du}{dx} = 2\,(a - x)$, which being put $= 0$, we have $x = a$. The second differential co-efficient $\frac{d^2u}{dx^2} = 2$, a negative quantity, therefore the function has a maximum value (art. 63), viz. when $x = a$; and that value is $u = a^2$, as is indeed evident from the nature of the function.

Ex. 2. Let $u = x^2 + 3x + 2$; then $\frac{du}{dx} = 2x + 3$. This put $= 0$, gives $x = -\frac{3}{2}$. Again, $\frac{d^2u}{dx^2} = 2$, a positive quantity, therefore the function is a *minimum* when $x = -\frac{3}{2}$. In that case $u = -\frac{1}{4}$.

Ex. 3. Let $u = x^3 - 15\,x^2 + 56x - 60$. Here

$$\frac{du}{dx} = 3x^2 - 30\,x + 56,\quad \frac{d^2u}{dx^2} = 6x - 30.$$

The equation $\frac{du}{dx} = 3x^2 - 30x + 56 = 0$ being resolved, we find $x = \frac{15 \pm \sqrt{57}}{3}$. Making $x = \frac{15 \pm \sqrt{57}}{3}$, we find $\frac{d^2u}{dx^2} = 6x - 30 = \pm 2\sqrt{57}$. Hence it appears that the function has a *minimum*, and also a *maximum* value; the former corresponding to $x = \frac{15 + \sqrt{57}}{3}$, and the latter to $x = \frac{15 - \sqrt{57}}{3}$.

If $x = \frac{15 + \sqrt{57}}{3}$, $u = -30 - \frac{38}{9}\sqrt{57}$, a *minimum.*

If $x = \frac{15 - \sqrt{57}}{3}$, $u = -30 + \frac{38}{9}\sqrt{57}$, a *maximum.*

Ex. 4. Let $u = x^5 - 5x^4 + 5x^3 + 1$;

then $\frac{du}{dx} = 5x^4 - 20x^3 + 15x^2 = 5x^2(x^2 - 4x + 3)$;

$$\frac{d^2u}{dx^2} = 20x^3 - 60x^2 + 30x = 10x(2x^2 - 6x + 3).$$

The equation $\frac{du}{dx} = 5x^2(x^2 - 4x + 3) = 0$,

gives four values of x, viz. $x = 3$, $x = 1$, the other two are $= 0$.

These being substituted in $\frac{d^2u}{dx^2}$, show that the function has a *maximum* and *minimum:*

when $x = 3$, $u = -26$, a *minimum ;*
$x = 1$, $u = 2$, a *maximum ;*

when $x = 0$, then $\frac{d^2u}{dx^2}$ vanishes, therefore there is neither *maximum* or *minimum* in this case.

Ex. 5. To determine the *maxima* and *minima* values of the function $y = x^x$; we have found (art. 24, ex. 2), that

$$\frac{dy}{dx} = x^x(1 + \text{l.}\,x);$$

and hence $\frac{d^2y}{dx^2} = x^x\left\{\frac{1}{x} + (1 + \text{l.}\,x)^2\right\}$;

The function x^x cannot be $= 0$; we must therefore put $1 + \text{l.}\,x = 0$;

$$\text{hence l.}\,x = -1, \text{ and } x = e^{-1} = \frac{1}{e}.$$

This value of x, substituted in the second differential coefficient, makes

$$\frac{d^2u}{dx^2} = \left(\frac{1}{e}\right)^{\frac{1}{e}} \cdot e, \text{ a positive quantity;}$$

therefore, when $x = \frac{1}{e}$, $x^x = \left(\frac{1}{e}\right)^{\frac{1}{e}}$, a *minimum.*

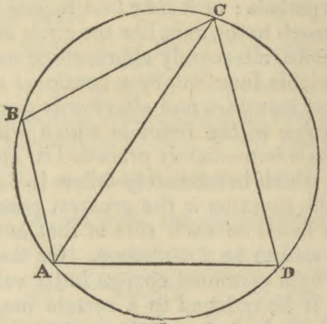
Ex. 6. To find the greatest space that can be enclosed by four given straight lines:

Let the given lines be $AB = a$, $BC = b$, $CD = e$, $DA = f$: Let $x =$ angle B, $v =$ angle D, $y =$ the area ABCD: Draw the diagonal AC.

By trigonometry, $a^2 + b^2 - 2ab \cos x = AC^2$,
$e^2 + f^2 - 2ef \cos v = AC^2$;

Hence, $2ab \cos x - 2ef \cos v = a^2 + b^2 - e^2 - f^2$.........(1)

Fig. 1.



And because trian. $ABC = \frac{1}{2}ab \sin x$; trian. $ADC = \frac{1}{2}ef \sin v$,

therefore, $y = \frac{1}{2}ab \sin x + \frac{1}{2}ef \sin v$.........................(2)

This last equation by differentiation gives, by the nature of a maximum,

$\frac{dy}{dx} = \frac{1}{2}ab \cos x + \frac{1}{2}ef \frac{dv}{dx} \cos v = 0$.....................(3)

By differentiating equation (1), we find

$$ab\,dx \sin x - ef\,dv \sin v = 0;$$

and hence $ef\frac{dv}{dx} = -ab\frac{\sin x}{\sin v}$:

Therefore, from eq. (3), $ab\left\{\cos x + \frac{\sin x \cos v}{\sin v}\right\} = 0$;

and hence $\sin v \cos x + \cos v \sin x = 0$;

that is (ALGEBRA, art. 239), $\sin(x+v) = 0$, and $x + v = \pi$.

Thus it appears that the opposite angles B, D must together make two right angles; therefore the figure will be a *maximum* when it is inscribed in a circle; and since in this case

$$\cos x = -\cos v, \ \sin x = \sin v;$$

from equations (1) and (2),

$$2(ab+ef)\cos x = a^2 + b^2 - e^2 - f^2,$$
$$2(ab+ef)\sin x = 4y.$$

By squaring both sides of these equations, and adding, and observing that $\cos^2 x + \sin^2 x = 1$, we have

$$4(ab+ef)^2 = (a^2+b^2-e^2-f^2)^2 + 16y^2,$$

and $16y^2 = 4(ab+ef)^2 - (a^2+b^2-e^2-f^2)^2$.

The right-hand side of this formula admits of being resolved into these two factors, viz.

$$2ab + 2ef + a^2 + b^2 - e^2 - f^2 = (a+b)^2 - (e-f)^2,$$
$$2ab + 2ef - a^2 - b^2 + e^2 + f^2 = (e+f)^2 - (a-b)^2;$$

and these again admit of this further resolution,

$$(a+b+e-f)\,(a+b-e+f),$$
$$(e+f+a-b)\,(e+f-a+b);$$

If we now put $s = \frac{1}{2}(a+b+e+f)$,

we have $a+b+e-f = 2(s-f)$,
$a+b-e+f = 2(s-e)$,
$e+f+a-b = 2(s-b)$,
$e+f-a+b = 2(s-a)$.

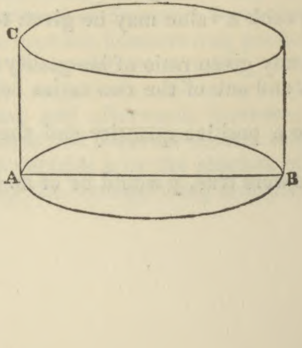
Hence $16y^2 = 16(s-a)(s-b)(s-e)(s-f)$;

and $y = \sqrt{(s-a)(s-b)(s-e)(s-f)}$.

We have now found by the calculus an elegant geometrical theorem.

Ex. 7. To determine the dimensions of a cylindric measure, open at top, which shall contain a given quantity of grain, liquor, &c. under the least internal superficies.

Fig. 2.



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Let $x = AB$ be the diameter of the base, $v = AC$ its depth, π the number 3·1416 (viz. half the circumference of a circle whose rad. = 1), and c the content of the cylinder. By GEOMETRY, the area of the base $= \frac{\pi x^2}{4}$, and its circumference $= \pi x$, and the internal surface of the cylinder $= v\pi x$. Now, the content of the cylinder $c = \frac{\pi x^2 v}{4}$; and therefore $v = \frac{4c}{\pi x^2}$; therefore the internal surface $= \frac{4c}{x}$; and putting y for the whole inside surface of the measure,

$$y = \frac{\pi x^2}{4} + \frac{4c}{x},$$

$$\text{therefore, } \frac{dy}{dx} = \frac{\pi x}{2} - \frac{4c}{x^2} = 0;$$

$$\frac{d^2y}{dx^2} = \frac{\pi}{2} + \frac{8c}{x^3}.$$

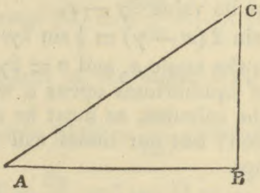
The first of these equations gives

$$\pi x^3 = 8c = 2\pi x^2 v, \text{ and } x = 2v;$$

hence the diameter of the base must be twice the depth: The second differential co-efficient being a positive quantity, shows the surface to be a *minimum.*

Ex. 8. A candle stands on a horizontal table, directly over a point at a given distance from a small object on the table; what ought to be the height of the flame when the object is illuminated the most possible.

Fig. 3.



Let A be the object on the table, B the point under the candle, and C the flame, considered as condensed at a point. The intensity of the illumination on the object A depends on its distance from C, and on the angle which the rays make with the surface (supposed to be horizontal). By the principles of optics, the intensity at different distances, the angle of obliquity being the same, will be inversely as the square of the distance; and with different degrees of obliquity, the distance being the same, as the sine of the angle which the rays make with the surface. Therefore the intensity, as depending on both obliquity and distance, will be expressed by

$$\frac{1}{AC^2} \sin CAB = \frac{BC}{AC^3}.$$

Put $a = AB$, $x = \sin CAB$, and let y denote the illuminating power on the surface at A; then

$$y = \frac{BC}{AC} \times \frac{AB^2}{AC^2} \times \frac{1}{AB^2} = \frac{\sin x \cos^2 x}{a^2},$$

$$\frac{dy}{dx} = \left\{ \cos^3 x - 2 \sin^2 x \cos x \right\} \frac{1}{a^2} = 0;$$

hence, $2 \sin^2 x \cos x = \cos^3 x$,

$$\text{and } \frac{\sin^2 x}{\cos^2 x} = \frac{1 - \cos 2x}{1 + \cos 2x} = \tfrac{1}{2}, \text{ and } \cos 2x = \tfrac{1}{3}.$$

By the trigonometrical tables, $2x = 70° 32'$, and $x = 35° 16'$; this gives $BC = AB \times .71$ nearly: so that the height of the flame must be about $\frac{7}{10}$ of the distance AB.

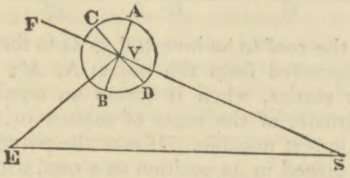
Ex. 9. To find the position of the planet Venus in respect of the earth and sun when her light is the greatest.

Direct Method.

The planet does not appear brightest when her disc is perfectly round; she is then too remote to produce that effect; and besides, she is seen in the direction of the sun. In her inferior conjunctions her crescent is too narrow, almost the whole illuminated part being turned towards the sun. It is therefore in some intermediate position, which is to be determined, that she is brightest.

Let S be the sun, E the earth, and ACBD Venus, ADB its illuminated hemisphere which is turned towards the sun, and CBD its hemisphere towards the earth: produce S V to F.

Fig. 4.



The portion of the illuminated surface turned towards the earth is contained between two planes DV, BV, perpendicular to the plane EVS; and this surface will manifestly be projected into a crescent, the breadth of which is the versed sine of the angle BVD, which is equal to EVF, because if BVE be added to both, each is a right angle. Now the area of the crescent is always as its breadth; therefore, the whole disk being taken as an unit, the illuminated part of it will be expressed by the versed sine of the angle EVF, or by $1 + \cos EVS$.

Again, the brightness of the planet at different distances is inversely as the square of the distance; therefore the brightness depending on its position in respect of the sun and its distance from the earth jointly, will be proportional to $\frac{1 + \cos EVS}{EV^2}$.

Let $a = ES$ the distance of the earth from the sun,
$b = VS$ the distance of Venus from the sun,
$x = VE$ the distance of Venus from the earth;

$$\text{Then, } \cos EVS \frac{x^2 + b^2 - a^2}{2bx},$$

$$\text{and } 1 + \cos EVS = \frac{x^2 + 2bx + b^2 - a^2}{2bx}.$$

$$= \frac{(x + b + a)(x + b - a)}{2bx};$$

therefore, putting y to denote the brightness of the planet,

$$y = \frac{(x + b + a)(x + b - a)}{2bx^3} \text{ a } maximum;$$

and this, by differentiation, gives

$$\frac{dy}{dx} = \frac{(x + b + a)(x + b - a)}{2bx^3} \left\{ \frac{1}{x + b + a} + \frac{1}{x + b - a} - \frac{3}{x} \right\} = 0;$$

$$\text{and hence, } \frac{3(a^2 - b^2) - 4bx - x^2}{2bx^4} = 0;$$

$$x^2 + 4bx = 3(a^2 - b^2),$$

$$x = \pm \sqrt{3a^2 + b^2} - 2b.$$

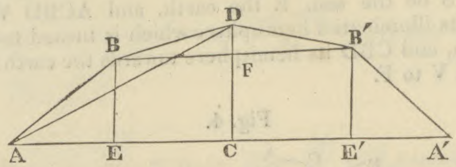
The negative value of x is not applicable, and we have

$$x = \sqrt{3a^2 + b^2} - 2b.$$

In numbers, $a = 10000$, $b = 7233$, therefore $x = 4304$, the angles $E = 39° 43' 30''$, $V = 117° 55' 20''$, $S = 22° 21' 10''$.

Ex. 10. Let ABDB′A′ be a kirb roof supported by four rafters AB, BD, DB′, B′A′, two and two of which are equal, viz. AB = A′B′, and BD = B′D, and all perfectly free to turn about the points A, B, D, B′, A′, as joints. Suppose also that AA′ the span, and DC the height of the roof, are given, and that AB has to BD a given ratio. Determine the position of the rafters when by their weight they form an equilibrium.

Fig. 5.



Suppose the roof to be inverted so as to form a polygon hanging suspended from the points A, A′; by a known principle in statics, when it forms an equilibrium, the centre of gravity of the mass of matter in the polygon will be the lowest possible. If now the polygon were reversed and placed in its position as a roof, without changing the angles at the joints, the equilibrium would not be disturbed, and in this position the centre of gravity would be the highest possible.

Draw a line from B to B′, which will be parallel to AA′; and draw the perpendiculars BE, B′E′. Put the angle BAC = B′A′C = x, DBF = DB′F = v; let the given ratio of AB to BD be that of a given number m to a given number n; these numbers may represent the length, also the weight, of the rafters, which may be supposed placed in their centres of gravity, or middle of the beams.

By trigonometry, BE = m sin x, DF = n sin v, therefore DC = $m \sin x + n \sin v$; and, by statics, the height of the centre of gravity of AB, also of A′B′, above AA will be $\frac{1}{2}$ BE = $\frac{1}{2} m \sin x$, and the height of the centre of gravity of BD, also of B′D, will be $\frac{1}{2}$ (BE + DC) = $m \sin x + \frac{1}{2} n \sin v$; and since the distance of the common centre of gravity of all the beams from AA′ will be found by multiplying the distance of each centre by the mass, supposed placed at that centre, and adding the results into one sum, and dividing by the sum of all the masses; the height of the centre of gravity of the whole system of beams above AA′ will be

$$\frac{m^2 \sin x + n\,(2\,m \sin x + n \sin v)}{2\,(m+n)}.$$

Let this height be denoted by y; then, rejecting the constant denominator $2\,(m+n)$,

$y = (m^2 + 2\,mn) \sin x + n^2 \sin v$, a maximum;

and since AC, half the span of the roof, is a given quantity, we have

$m \cos x + n \cos v =$ AC, *a constant.*

From the first equation,

$$\frac{dy}{dx} = (m^2 + 2\,mn) \cos x + n^2 \cos v \frac{dv}{dx} = 0;$$

and from the second,

$$m \sin x + n \sin v \frac{dv}{dx} = 0; \text{ hence } \frac{dv}{dx} = -\frac{m \sin x}{n \sin v}.$$

This value of $\frac{dv}{dx}$ being substituted in the value of $\frac{dy}{dx}$, we obtain

$$(m^2 + 2\,mn) \cos x - \frac{mn \cos v \sin x}{\sin v} = 0;$$

and from this again,

$$\frac{\tan x}{\tan v} = \frac{m}{n} + 2 \ldots\ldots\ldots\ldots\ldots\ldots (1.)$$

This formula expresses a property of all roofs made of four beams, which are equal two and two, when by their position they form an equilibrium.

Join AD, and put $\gamma =$ angle DAC which is known, because $\tan \gamma = \frac{\text{DC}}{\text{AC}}$. The angle BAD $= x - \gamma$, and BDA $= \gamma - v$. Now, in the triangle ABD, sin A : sin D = DB : BA, that is, $\sin (x - \gamma) : \sin (\gamma - v) = n : m$; therefore,

$$\frac{\sin (x - \gamma)}{\sin (\gamma - v)} = \frac{n}{m} \ldots\ldots\ldots\ldots (2.)$$

These equations (1), (2), determine the angles x, v, when the ratio of AB to BD is given; from their form, the angles may be easily found by trials in the trigonometrical tables. The elimination of one of the angles would produce an equation of the fourth degree; for this reason, the method of trials is the best way of proceeding. When the angles x and v are known, every thing else may be readily found.

If we suppose the beams AB, BD, to be of equal length, then $m = n$, and our two equations become

$$\frac{\tan x}{\tan v} = 3, \quad \sin (x - \gamma) = \sin (\gamma - v).$$

In this case, $x + v = 2\gamma$; then, from the equation

$$\frac{\tan x}{\tan v} = \frac{\sin x \cos v}{\cos x \sin v} = 3,$$

we get $\frac{\sin x \cos v - \cos x \sin v}{\sin x \cos v + \cos x \sin v} = \frac{\sin (x - v)}{\sin (x + v)} = \frac{1}{2}$;

and hence $\sin (x - v) = \frac{1}{2} \sin (x + v) = \frac{1}{2} \sin 2\gamma$;

and putting for v its value $2\gamma - x$,

$$\sin 2\,(x - \gamma) = \tfrac{1}{2} \sin 2\gamma.$$

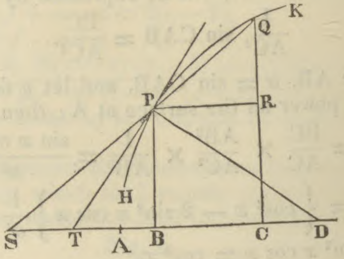
This determines the angle x, and $v = 2\gamma - x$.

The theory of equilibriums opens a wide field for the application of the calculus, as must be evident from the preceding solution; but our limits will not permit us to enter on it farther.

Determination of Tangents to Curves.

65. Let HPK be any curve referred to an axis AC; and let AB = x and PB = y be the co-ordinates of any point P in the curve; the point A being the origin of the abscisses. Let PT, a tangent to the curve at P, meet the axis in T; and let SPQ, any straight line drawn through P, meet the curve in Q and the axis in S. Draw QC perpendicular to the axis, and PR perpendicular to QC; and let PR = BC = h, and QC = y', the ordinate corresponding to the absciss $x + h$.

Fig. 6.



By similar triangles, QR : RP = PB : BS, that is,

$y' - y : h = y :$ BS.

Now, by Taylor's theorem (art. 31),

$$y' - y = \frac{dy}{dx} h + \frac{d^2y}{d^2x} h^2 + \&\text{c}.$$

hence, dividing the first antecedent and consequent by h,

$$\frac{dy}{dx}+\frac{d^2y}{dx^2}h+\text{ \&c.}:1=y:\text{BS}.$$

This proposition holds true whatever be the magnitude of h, the increment of x. But now let us suppose h to decrease continually; the point Q will approach to P, and the line QPS approaching to coincidence with PT, the point S will approach to T; and when h vanishes, Q will be at P, and S at T, and BS will have become BT; our proportion will now be

$$\frac{dy}{dx}:1=y:\text{BT}.$$

The line BT, between the ordinate PB and tangent PT, is called the *subtangent;* from this proportion it appears, that x and h being co-ordinates at any point in the curve,

$$\text{BT, the subtangent, }=y\div\frac{dy}{dx}=y\frac{dx}{dy};\ldots\ldots\ldots\ldots(1)$$

that is, the subtangent is equal to the ordinate divided by its differential co-efficient; or it is a third proportional to the differential of the ordinate, the differential of the abscissa and the ordinate. The subtangent being known, the position of the tangent is determined.

Let PD, a perpendicular to the tangent at P, and consequently to the curve, meet the axis in D; the line PD is called a *normal* to the curve; and BD, the segment of the axis between the ordinate and normal, is called the *subnormal.*

The triangles TBP, PBD are similar, therefore

$$\text{TB}:\text{BP}=\text{BP}:\text{BD},\text{ or }dx:dy=y:\text{BD},$$

$$\text{hence the } \textit{subnormal} \text{ BD}=y\frac{dy}{dx}\ldots\ldots\ldots(2).$$

Because the tangent of the angle $\text{PTB}=\frac{\text{PB}}{\text{TB}}$, and the tangent of the angle $\text{PDB}=\frac{\text{PB}}{\text{BD}}$; therefore,

$$\tan \textit{angle}\ \text{T}=\frac{dy}{dx},\text{ and }\tan\text{D}=\frac{dx}{dy}\ldots\ldots\ldots(3).$$

In the right-angled triangles TBP, PBD, we have $\text{PT}^2=\text{PB}^2+\text{BT}^2$, and $\text{PD}^2=\text{PB}^2+\text{BD}^2$; therefore,

$$\textit{tangent}\ \text{PT}=y\sqrt{1+\frac{dx^2}{dy^2}}\ \ldots\ldots\ldots\ldots\ldots\ (4)$$

$$\textit{normal}\ \text{PD}=y\sqrt{1+\frac{dy^2}{dx^2}}\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

66. We shall now apply these general formulæ to some particular curves.

Ex. 1. Let the curve be the parabola, and supposing AC to be the axis, and A its vertex: by the nature of the curve, putting a for the parameter, $y^2=ax$,

$$\text{hence } 2ydy=adx;\ \frac{dx}{dy}=\frac{2y}{a},$$

$$\text{subtan. BT}=\frac{dx}{dy}y=\frac{2y^2}{a}=\frac{2ax}{a}=2x;$$

that is, the subtangent is double the absciss AB.

Again, for the subnormal, we have

$$\text{subnor. BD}=\frac{dy}{dx}y=\frac{adx}{2dx}=\frac{a}{2}.$$

Thus it appears that the subnormal is constant, and equal to half the parameter.

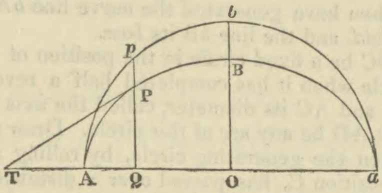
Ex. 2. Let the curve be an ellipse, of which OA half the greater axis $=a$, OB half the lesser axis $=b$; and supposing the origin of the co-ordinates to be at O the centre, let $\text{OQ}=x$, $\text{PQ}=y$. By the nature of the curve,

$$a^2:b^2=(a+x)(a-x):y^2\text{ (Conics)};$$

$$\text{hence } y^2=\frac{b^2}{a^2}(a^2-x^2),\text{ and } ydy=-\frac{b^2xdx}{a^2};$$

$$\text{and subtan. QT}=\frac{dx}{dy}y=-\frac{a^2y^2}{b^2x}=-\frac{a^2-x^2}{x}=-\left(\frac{a^2}{x}-x\right).$$

Fig. 7.



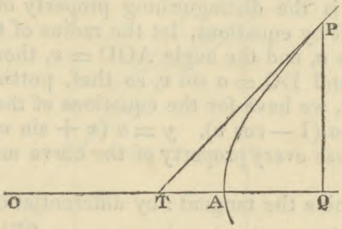
The general formula for the subtangent was found on the hypothesis that it was on the same side of the ordinate as the absciss; in this case they are supposed to be on opposite sides, and hence its value has the negative sign; leaving the direction of the subtangent in respect of the absciss out of consideration, we have

$$\text{QT}=\frac{a^2}{x}-x,\text{ and OT}=\frac{a^2}{x},$$

hence it appears that OQ : OA = OA : OT.

When the axes are equal, the ellipse becomes a circle, but the subtangent is independent of the ratio of the axes.

Fig. 8.



Ex. 3. Let the curve be the hyperbola, of which $a=\text{OA}$ the semitransverse axis, and $b=$ the semiconjugate; then, putting $\text{OQ}=x$, and $\text{PQ}=y$, we have (by Conics),

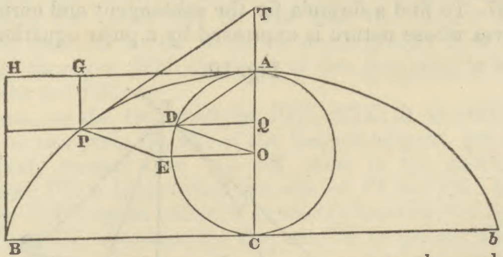
$$y^2=\frac{b^2}{a^2}(x^2-a^2),\quad ydy=\frac{b^2}{a^2}xdx;$$

$$\text{subtan. QT}=\frac{dx}{dy}y=\frac{a^2y^2}{b^2x}=\frac{x^2-a^2}{x}=x-\frac{a^2}{x};$$

$$\text{hence OT}=\text{OQ}-\text{QT}=\frac{a^2}{x}.$$

This shows that the tangent always passes between the centre and the vertex when x has a finite value; but when x becomes infinite, then $\text{OT}=0$, and the tangent becomes an asymptote to the hyperbola.

Fig. 9.



Ex. 4. We shall next draw a tangent to the cycloid; but first the nature of the curve must be expressed analytically. Conceive a circle to roll along a straight line, moving always in the same plane, just as the wheel of a carriage rolls along a straight road. By this motion any given point in the circumference of the circle will describe

Direct Method.

a continuous curve in that plane, which will meet the line along which it rolls at intervals equal to its circumference.

Let bB be the line along which a circle CDA rolls, beginning its motion from a point of contact b, and completing a revolution when it has come to B. The point of the circumference which was in contact with the line at b will then have generated the curve line bAB. This is the *cycloid*, and the line bB its *base*.

Let ADC be a fixed circle in the position of the *generating* circle when it has completed half a revolution, O its centre, and AC its diameter, called the axis of the cycloid. Let AD be any arc of this circle. Draw the radius OD. When the generating circle, by rolling along CB from the position C, has passed over a distance equal to the arc AD, the centre O will have generated a straight line OE parallel to CB, and equal to the same arc AD; moreover, the moveable radius, which was coincident with OA, will, by the rotation of the circle, have come into a position EP, parallel to OD, because the angular motion of the radius about the moving point E will always be proportional to the arc of the circle that has been applied to the base, that is, by hypothesis, to the arc AD; and since the lines OD, EP are equal and parallel, a straight line drawn from P through D, meeting AC in Q, will be parallel to EO, and therefore perpendicular to AC; and since PD = OE = arc AD, it follows that PQ, any ordinate to the axis AC, is equal to the sum of the arc AD and its sine DQ. This is the distinguishing property of a cycloid. To express it by equations, let the radius of the generating circle be a, and the angle AOD $= v$, then PD = arc AD $= av$, and DQ $= a \sin v$, so that, putting AQ $= x$, and PQ $= y$, we have for the equations of the curve

$$x = a\,(1 - \cos v), \quad y = a\,(v + \sin v);$$

and from these every property of the curve may be investigated.

To determine the tangent: by differentiation,

$$dx = a \sin v, \quad dy = adv\,(1 + \cos v), \quad \frac{dx}{dy} = \frac{\sin v}{1 + \cos v},$$

$$\text{subtan QT} = y\frac{dx}{dy} = \frac{(v + \sin v) \sin v}{1 + \cos v} = \frac{\text{PQ . QD}}{\text{CQ}};$$

hence CQ : DQ = PQ : QT.

But by the nature of the circle CQ : DQ = DQ : QA; therefore PQ : QT = DQ : QA; hence the triangles PQT, DQA are similar, and the tangent PT is parallel to the chord DA.

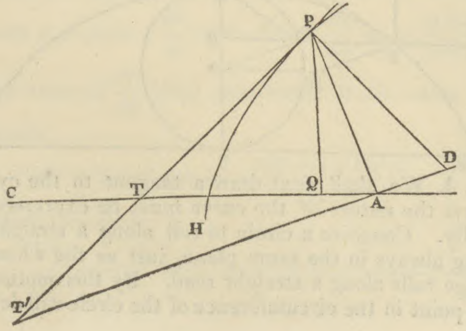
Ex. 5. In the logarithmic curve of which the equation is $y = a^x$, we have $dy = a^x\,.\,\text{l.}\,a\,.\,dx = y\,\text{l.}\,a\,.\,dx$; therefore

$$\frac{dx}{dy}y = \frac{1}{\text{l.}\,a} = \text{subtangent.}$$

Hence it appears that the subtangent is a line of a constant given length.

67. To find a formula for the subtangent and normal of curves whose nature is expressed by a polar equation.

Fig. 10.



Let HPK be such a curve, generated by the revolution of a variable radius AP about a given point A in AC, a line given in position. Through A draw AT′ perpendicular to AP; let a tangent to the curve at P meet this line in T′ and the axis in T; draw PQ perpendicular to the axis AC, and draw the normal PD, meeting T′A in D. Then AT′ is the subtangent and AD the subnormal. Let AQ $= x$, PQ $= y$, the revolving radius AP $= r$, the variable angle PAC $= v$, and the angle PTA $= t$. The lines x, y, r are now to be considered as functions of the angle v.

The angle T′PA being the supplement of the sum of PTA and PAT; that is, of $v + t$, we have (ALGEBRA, art. 236 and 242),

$$\tan \text{angle T'PA} = -\tan\,(v + t) = \frac{\tan v + \tan t}{\tan v \tan t - 1}.$$

$$\text{Now } \tan v = \frac{y}{x}, \text{ and } \tan t = \frac{\text{PQ}}{\text{TQ}} = -\frac{dy}{dx};$$

$$\text{therefore } \tan \text{T'PA} = \frac{\dfrac{y}{x} - \dfrac{dy}{dx}}{-\dfrac{ydy}{xdx} - 1} = \frac{xdy - ydx}{xdx + ydy}.$$

$$\text{Again, } \frac{xdy - ydx}{x^2} = d\left(\frac{y}{x}\right) = d\,(\tan v) = \frac{dv}{\cos^2 v},$$

$$\text{therefore } xdy - ydx = dv\frac{x^2}{\cos^2 v} = r^2dv;$$

$$\text{and } xdx + ydy = \tfrac{1}{2}d\,(x^2 + y^2) = \tfrac{1}{2}d\,(r^2) = rdr;$$

$$\text{therefore } \tan \text{T'PA} = \frac{r^2dv}{rdr} = \frac{rdv}{dr};$$

and since by trigonometry T′A = AP tan TPA, therefore

$$\text{subtangent T'A} = \frac{dv}{dr}r^2;$$

also, since T′A : AP = AP : AD; therefore

$$\text{subnormal AD} = \frac{dr}{dv}.$$

Ex. Let the curve PH be the spiral of Archimedes, the nature of which is defined by the equation $2\pi r = av$, where $\pi = 2$ right angles, and a is a given line, viz. the value of r when $v = 2\pi$. In this case

$$\text{subtangent} = \frac{dv}{dr}\,.\,r^2 = \frac{2\pi r^2}{a}.$$

68. In some curves the segment of the axis between the origin of the co-ordinates and the tangent increases with the variable x, and may exceed any given line. In others the tangent cuts the axis always at a finite distance from the origin; it is then an *asymptote* to the curve. If from the subtangent QT $= \frac{dx}{dy}y$ (fig. 8) the absciss AQ $= x$ be subtracted, the remainder $\frac{dx}{dy}y - x$ is the general expression for AT. Now if when x is infinite this expression is finite, we may conclude that the curve has asymptotes; but if it be infinite, the curve has no asymptotes.

In the conic hyperbola we found (ex. 3, art. 66) $\frac{dx}{dy}y = x - \frac{a^2}{x^2}$; therefore $\frac{dx}{dy}y - x = -\frac{a^2}{x^2}$; when x is infinite, the expression $-\frac{a^2}{x} = 0$, hence it follows that the hyperbola has an asymptote which passes through the centre.

In the parabola, ex. 1, we found $\frac{dx}{dy}y = \frac{2y^2}{ax}$, therefore

$\frac{dx}{dy}y - x = \frac{2y^2}{a} - x = 2x - x = x$. When x is infinite this quantity is also infinite, therefore the parabola has no asymptote.

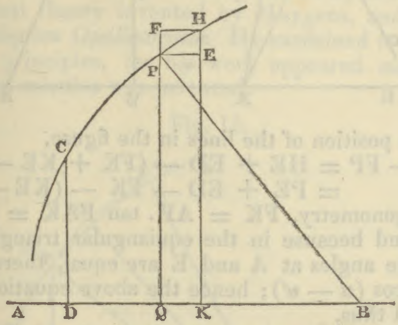
The method of drawing tangents to curves is an important branch of the theory of curve lines. It serves also to determine their greatest and least ordinates (which may also be found by the theory of *maxima* and *minima*), and many other circumstances relating to their figure.

Differential of the Area of a Curvilineal Space, and of the Arc of a Curve.

69. In curve lines it is convenient to consider x, one of the co-ordinates, as an independent variable quantity; and any area having an arc of the curve for a boundary, also the arc, and in general every other variable quantity connected with the curve, as functions of that variable. If the curve be expressed by a polar equation, the angle which the revolving radius makes with the variable may be taken as the independent variable, and the co-ordinates and other variable quantities related to the curve as functions of that angle.

We begin by investigating a formula for the area.

Fig. 11.



Let AB be the axis of any curve CP, A and C given points in the axis and curve, PQ, HK any two variable ordinates, and CD an ordinate given in position at the given point C; draw PE and HF perpendiculars to HK, PQ.

Put AQ $= x$, PQ $= y$, *curvilineal space* PQDC $= s$;
AK $= x'$, HK $= y'$, HKDC $= s'$;
then QK $= x' - x$, and PHKQ $= s' - s$.

The space PHKQ is greater than the rectangle PEKQ, but less than the rectangle FHKQ (supposing y to increase from the position PQ to HK), therefore,

$$s' - s > (x' - x)\,y,\quad s' - s < (x' - x)\,y';$$

$$\text{and } \frac{s' - s}{x' - x} > y,\quad \frac{s' - s}{x' - x} < y'.$$

Hence, since when HK approaches to coincidence with PQ, y' approaches to equality with y, we have

$$\frac{ds}{dx} = \text{lim.}\ \frac{s' - s}{x' - x} = y,$$

$$\text{and } ds = ydx \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1).$$

Thus it appears that *The differential of a curvilineal area is the product of the ordinate and the differential of the absciss.*

In the formula just found, the ordinates have been supposed perpendicular to the axis. If they be oblique, let α be the angle of inclination; then $s' - s$ will be greater than $(x' - x)\,y \,.\, \sin\alpha$, but less than $(x' - x)\,y' \,.\, \sin\alpha$; and hence, reasoning as before, we find

$$ds = \sin\alpha \,.\, ydx \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2).$$

70. To find a formula applicable when the nature of the curve is expressed by a polar equation, let B be the pole, and PB the variable radius.

Put PB $= r$, the angle PBQ $= v$, and the curvilineal space PCDB $= s$; also let BQ $= x$, PQ $= y$, then

$$ds = d\,(\text{space CDQP}) + d\,(\text{triangle PQB}).$$

Now d (space CDQP) $= -\,ydx$, which is negative, because x decreases when the space increases; and d (triangle PQB) $= d\,(\frac{1}{2}\,xy) = \frac{1}{2}\,ydx + \frac{1}{2}\,xdy$; therefore,

$$ds = -\,ydx + \tfrac{1}{2}\,ydx + \tfrac{1}{2}\,xdy = \tfrac{1}{2}\,(xdy - \tfrac{1}{2}\,ydx)$$
$$= x^2 d\left(\frac{y}{x}\right) \text{ (art. 12).}$$

But in the right-angled triangle PBQ,

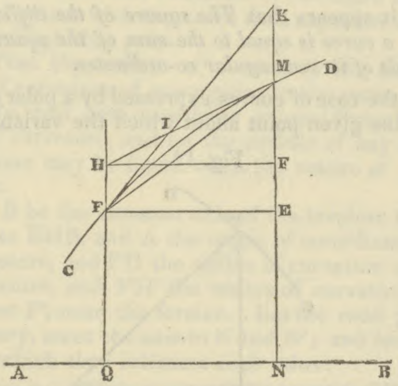
$$\text{BQ} = x = r\cos v,\quad \frac{y}{x} = \tan v,\quad d\left(\frac{y}{x}\right) = \frac{dv}{\cos^2 v} \text{ (art. 22)};$$

$$\text{hence } ds = \tfrac{1}{2}\,r^2 dv \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3).$$

In this case *The differential of the area is half the product of the square of the revolving radius, and the differential of the angle which it makes with the axis.*

71. We have already found (art. 23) various expressions for the differential of the arc of one particular curve, viz. the circle. We shall now investigate general expressions for the differential of the arc of any curve. For this purpose it will be convenient to establish the following geometrical proposition.

Fig. 12.



Let CPMD be a curve, that between the points P and M continually approaches to or continually recedes from an axis AB. Let PQ, MN be ordinates to the axis at the extremities of the arc PM, and PK, MH tangents to the curve at the points P, M, meeting the ordinates in K and H: The length of the arc is always of an intermediate magnitude between the lengths of the tangents PK, MH.

Draw the chord PM, and let I be the intersection of the tangents. It is easy to see that PK, one of the tangents, meets the parallel ordinates in an angle K more acute than M, the angle made by the chord PM and ordinate MN; and the other in an angle H less acute; therefore the chord will be less than the former and greater than the latter. Now the arc is greater than the chord; therefore MH, the least of the tangents, is less than the arc PM.

Again, in the two triangles PIH, MIK, it is evident that the two parts PI, IK, of the longest tangent, are respectively greater than HI, IM, those of the shorter; therefore PK is longer than the sum of PI and IM; but the arc PM is by an axiom of geometry less than the sum of PI and IN, therefore the tangent PK is greater than the arc PM.

72. Let A be a given point in the axis, and C in the curve; draw PE, HF parallel to AB; put AQ $= x$, AN $= x'$, PQ $= y$, CP $= z$, CM $= z'$; then PE $= x' - x$, and arc PM $= z' - z$. Because PM $= z' - z$ is less than PK, but greater than MH, therefore

Direct Method.

$$\frac{z'-z}{x'-x} < \frac{\mathrm{PK}}{\mathrm{PE}}, \text{ and } \frac{z'-z}{x'-x} > \frac{\mathrm{HM}}{\mathrm{HF}}.$$

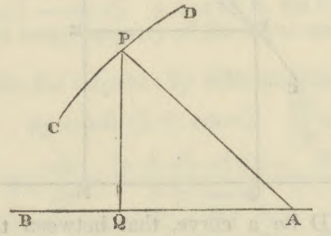
Now $\frac{\mathrm{PK}}{\mathrm{PE}}$ and $\frac{\mathrm{HM}}{\mathrm{HF}}$ are the secants of the angles KPE and MHF; therefore the ratio $\frac{z'-z}{x'-x}$ is expressed by a quantity less than the secant of one of these angles, and greater than the secant of the other angle. Suppose now $z'-z$ and $x'-x$, the terms of the ratio, to be continually diminished; the angles at H and P will approach to equality, and at last become equal, therefore the limit of the ratio, viz. $\frac{dz}{dx}$, is equal to the secant of the angle KPE; but it was shown (art. 65) that the tangent of the angle which a line touching a curve makes with the axis, or any line parallel to the axis, is equal to $\frac{dy}{dx}$, and consequently its secant to $\sqrt{1+\frac{dy^2}{dx^2}}$; therefore

$$\frac{dz}{dx}=\sqrt{1+\frac{dy^2}{dx^2}} \text{ and } dz=\sqrt{dx^2+dy^2}\ldots\ldots\ldots\ldots(1)$$

Hence it appears that *The square of the differential of the arc of a curve is equal to the sum of the squares of the differentials of its rectangular co-ordinates.*

73. In the case of curves expressed by a polar equation, let A be the given point about which the variable radius AP turns; put v for the variable angle which the line AP $= r$ makes with AB, a line given in position; let the rectangular co-ordinates be AQ $= x$, PQ $= y$; then

Fig. 13.



$$x = r\cos v,\ y = r\sin v;$$

$$dx = -r\sin v\,dv + \cos v\,dr = -ydv + \frac{x}{r}dr;$$

$$dy = r\cos v\,dv + \sin v\,dr = xdv + \frac{y}{r}dr;$$

$$dx^2 = y^2dv^2 + \frac{x^2}{r^2}dr^2 - \frac{2xy}{r}dvdr;$$

$$dy^2 = x^2dv^2 + \frac{y^2}{r^2}dr^2 + \frac{2xy}{r}dvdr;$$

$$\text{therefore, } dx^2+dy^2=(x^2+y^2)\left(dv^2+\frac{dr^2}{r^2}\right).$$

$$\text{But } dx^2+dy^2=dz^2, \text{ and } x^2+y^2=r^2;$$
$$\text{therefore, } dz^2=r^2dv^2+dr^2,$$
$$\text{and } dz=\sqrt{r^2dv^2+dr^2}\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

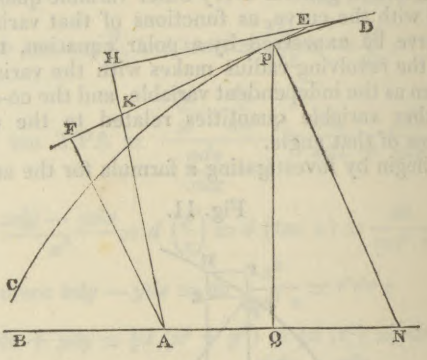
This formula gives the differential of an arc of a curve in terms of the differential of the variable *radius vector*, and the angle which it makes with the axis.

74. We shall now give a method of defining a curve by a polar equation, which leads to a simple and elegant expression for the differential of an arc of the curve.

Let CPD be any curve, and A a given point in AB, a line given by position; draw a tangent PF at any point P in the curve, and a perpendicular AF from the given point A on the tangent; if now we know the relation between the perpendicular AF, and the angle FAB, which it makes with the line AB, the length of the perpendicular corresponding to any given value of the angle can be found; thus the position of the tangent will be known; the calculus gives a general formula for PF, the segment of the tangent between the point of contact and its intersection with the perpendicular; thus the point of contact P is known, and in this way may any number of points in the curve be determined.

75. Let D be another point in the curve, DH a tangent, and AH a perpendicular on the tangent, and let us put angle FAB $= u$, perp. AF $= p$, tan PF $= t$, arc CP $= z$;
HAB $= u'$, AH $= p'$, DH $= t'$, CD $= z'$

Fig. 14.



From the position of the lines in the figure,

$$\mathrm{HD}-\mathrm{FP}=\mathrm{HE}+\mathrm{ED}-(\mathrm{FK}+\mathrm{KE}-\mathrm{EP})$$
$$=\mathrm{PE}+\mathrm{ED}-\mathrm{FK}-(\mathrm{KE}-\mathrm{HE}).$$

By trigonometry, FK $=$ AF . tan FAK $= p\tan(u'-u)$; and because in the equiangular triangles AFK, EHK, the angles at A and E are equal, therefore HE $=$ KE . $\cos(u-u')$; hence the above equation may be expressed thus,

$$t-t'=\mathrm{PE}+\mathrm{ED}-p.\tan(u'-u)-\{1-\cos(u'-u)\}\mathrm{KE};$$

and dividing by $u'-u$,

$$\frac{t'-t}{u'-u}=\frac{\mathrm{PE}+\mathrm{ED}}{u'-u}-p.\frac{\tan(u'-u)}{u'-u}-\frac{1-\cos(u'-u)}{u'-u}\mathrm{KE}.$$

Suppose now the point D to approach to coincidence with P, we have these limits to the ratios:

$$\lim.\frac{t'-t}{u'-u}=\frac{dt}{du}; \qquad \lim.\frac{\mathrm{PE}+\mathrm{ED}}{u'-u}=\frac{dz}{du};$$

$$\lim.\frac{\tan(u'-u)}{u'-u}=1; \qquad \lim.\frac{1-\cos(u'-u)}{u'-u}$$

$$=\lim.\frac{2\sin^2\frac{1}{2}(u'-u)}{u'-u}=0;$$

hence, on the whole,

$$\frac{dt}{du}=\frac{dz}{du}-p, \text{ and } dz=dt+pdu,$$
$$\text{or } d(z-t)=pdu.$$

In the figure from which the formula has been investigated, the arc and tangent lie in the same direction from the point of contact. If they had proceeded in contrary directions, the formula would have been $d(z+t)=pdu$, so that, in general,

$$d(z\mp t)=pdu\ldots\ldots\ldots\ldots\ldots(3)$$

The differential of the arc may be expressed independently of t; for

$$\mathrm{AH}-\mathrm{AF}=\mathrm{KH}+\mathrm{AK}-\mathrm{AF};$$

Now KH $=$ HE . tan HEK $=$ HE $\tan(u'-u)$, and AF $=$ AK $\cos(u'-u)$; therefore, dividing by $u'-u$, we have

Direct Method.

$$\frac{p' - p}{u' - u} = \mathrm{HE}\,\frac{\tan(u' - u)}{u' - u} + \frac{1 - \cos(u' - u)}{u' - u}\,\mathrm{AK}:$$

and, passing to the limits, observing that lim. HE $= t$,

$$\lim.\frac{\tan(u' - u)}{u' - u} = 1, \text{ and } \lim.\frac{1 - \cos(u' - u)}{u' - u} = 0,$$

we find $\frac{dp}{du} = t$; if the tangent and arc lie in contrary directions, then $-\frac{dp}{du} = t$, so that, including both cases in one formula, $t = \pm\frac{dp}{du}$.

The sign $+$ is to be taken when the arc and tangent lie in the same direction, but the sign $-$ when they have contrary directions; and because $dt = \pm\frac{d^2p}{du}$, therefore in every curve

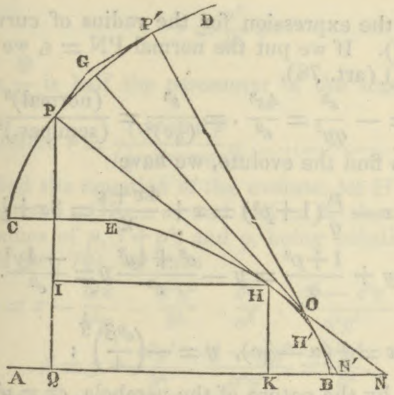
$$dz = pdu + \frac{d^2p}{du^2}\,du = \left(p + \frac{d^2p}{du^2}\right)du \ldots\ldots\ldots\ldots (4)$$

This is the formula which was to be found.

Generation of Curves by Evolution: Radius of Curvature: Evolutes.

76. The method of generating curves by evolution is a geometrical theory invented by Huygens, and given in his *Horologium Oscillatorium.* He explained it upon geometrical principles, for his work appeared many years before the calculus was invented.

Fig. 15.



Let BHE be a model of a plane curve made of a solid material, having some thickness, and let one end of a thread HEC be fastened at a point B on the edge of the model, and applied along its convexity, so as to coincide with it entirely between B and E, the remaining portion EC of the thread forming a straight line touching the curve at E. Suppose now the thread to be gradually unlapped from the curve BE, keeping it always tight; the end C will now describe another curve CPD.

All curves, in which the curvature is neither infinitely great nor infinitely small, may be generated in this way by the evolution of a thread from another curve.

77. The curve EHB, by means of which the curve CPD is generated, is called its EVOLUTE; and the curve CPD thus generated by evolution, is called the INVOLUTE of the other curve.

From the way in which the involute is generated from its evolute, we may infer,

(1.) That PH, the part of the thread disengaged from the arc EH, is a tangent to the evolute at H.

(2.) That the line PH is perpendicular to a tangent to the curve CPD at P, and that at the same time it describes an element of the curve, and an element of a circle whose momentary centre is H and radius HP.

(3.) That to a certain extent the part of the involute adjoining to P, and towards C, is *more* incurvated than a circle whose radius is PH; because, supposing P to proceed towards C, the variable radius PH is gradually becoming shorter. On the other hand, a portion of the curve from P towards D is *less* incurvated than a circle whose radius is CP, because the generating radius is continually becoming longer.

(4.) That since the curvature of the involute on one side of P, and adjoining to it, is less than that of a circle whose radius is PH, and the curvature on the other side of P is greater, it follows that at the point P the curvature of the involute is exactly the same as that of a circle described with the radius HP. The point H is therefore called the *centre of curvature* of the curve CPD in the point P; and PH, its *radius of curvature* at that point; and a circle described with the line PH is the *circle of equal curvature* with the curve at the point P. From the close union of the circle and curve they have been said to *osculate.* It must, however, be kept in mind that the two curves have no common segment; they meet in a geometrical point at P, and separate on both sides of it. We may also infer that the circle of curvature has a more intimate contact with the curve than any other circle that passes through that point.

(5.) That the evolute of a curve is the *locus* of the centre of curvature of every point in the curve.

78. We shall now investigate general formulæ for the radius of curvature, and for the evolute of any curve, by which these may be found when the nature of the curve is known.

Let AB be the common axis of the involute CPD, and its evolute EHB, and A the origin of co-ordinates; let H be the centre, and PH the radius of curvature at P; and H′ the centre, and P′H′ the radius of curvature of another point P′, near the former. Let the radii produced, if necessary, meet the axis in N and N′; and let O be the point in which they intersect each other.

Put AQ $= x$, PQ $= y$, arc CP $= z$, arc CP′ $= z'$, angle PNA $= v$, angle P′N′A $= v'$, rad. of curv. PH $= r$.

By trigonometry, PG = OG . sin POG; P′G = OG . sin P′OG; therefore, $\mathrm{OG} = \frac{\mathrm{PG} + \mathrm{P'G}}{\sin \mathrm{POG} + \sin \mathrm{P'OG}}$.

Suppose now the points P′, P to approach continually towards coincidence, the line GO will manifestly have for its limit PH, the radius of curvature at P. The limit of the sum of the tangents PG, P′G will be the arc PP′ $= z' - z$. The limit of the sines of the angles POG, P′OG will be the arcs which measure the angles, and that of the sum of the sines will be the measure of the angle POP = NON $= v' - v$. Hence it appears that $r =$ limit of $\frac{z' - z}{v' - v}$, and therefore, that

$$r = \frac{dz}{dv} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

This is our first general expression for the radius of curvature. Put $\frac{dy}{dx} = p$, $\frac{d^2y}{dx^2} = \frac{dp}{dx} = q$.

Because (art. 72) $dz = \sqrt{dx^2 + dy^2} = dx\sqrt{1 + \frac{dy^2}{dx^2}}$, therefore $dz = dx\sqrt{1 + p^2}$.

When treating of tangents to curves, we found (art. 65) that $\tan v = \frac{dx}{dy}$, therefore, $\tan v = \frac{1}{p}$, $\sec v = \frac{\sqrt{1 + p^2}}{p}$,

$$\text{and } d(\tan v) = dv \sec^2 v = -\frac{dp}{p^2};$$

$$\text{hence, } \frac{1+p^2}{p^2}dv = -\frac{qdx}{p^2}, \text{ and } dv = -\frac{qdx}{1+p^2}.$$

If now the values of dz and dv be substituted in our first formula for the radius of curvature, there is obtained

$$r = -\frac{1}{q}(1+p^2)^{\frac{3}{2}} = -\frac{(dx^2+dy^2)^{\frac{3}{2}}}{dxdy^2} \dots\dots\dots\dots (2)$$

This is a second general formula for the radius of curvature.

Let s denote the normal PN. In the right-angled triangle PQN, by trigonometry, $\sin \text{N} = \frac{\text{PQ}}{\text{PN}}$, that is, $\sin v = \frac{y}{s}$; but since

$$\tan v = \frac{dx}{dy} = \frac{1}{p}, \text{ therefore } \frac{y}{s} = \sin v = \frac{1}{\sqrt{1+p^2}},$$

$$\text{and } \sqrt{1+p^2} = \frac{s}{y}, \text{ and } (1+p^2)^{\frac{3}{2}} = \frac{s^3}{y^3}.$$

Referring now to our second formula, we have

$$r = -\frac{s^3}{qy^3} = -\frac{s^3}{y^3} \cdot \frac{dx^2}{dy^2} \dots\dots\dots\dots\dots\dots (3)$$

This is a third formula for the radius of curvature.

If we suppose the nature of the curve (see fig. 14, art. 74) expressed by an equation between AF $= p$, a perpendicular from a given point in the axis on a tangent PF, and FAP $= v$, the angle which that perpendicular makes with the axis, and therefore also equal to the angle which the normal PN makes with the axis; then, since $dz = \left(p + \frac{d^2p}{dv^2}\right)dv$; from formula (1) we get also

$$r = p + \frac{d^2p}{dv^2} \dots\dots\dots\dots\dots\dots (4)$$

This is a fourth formula for the radius of curvature.

79. To determine the nature of the evolute EHB, from any point H in the curve draw HK perpendicular to AB, and HI perpendicular to PQ; and assuming A, the origin of the co-ordinates of the involute also as the origin of those of the evolute, let AK $= \alpha$, HK $= \beta$; in the triangle PHI, HI $=$ PH . cos H $= r \cos v$, and PI $= r \sin v$, therefore

$$\alpha = x + r\cos v, \qquad \beta = y - r \sin v.$$

We have found that $\tan v = \frac{1}{p}$, and therefore

$$\cos v = \frac{p}{\sqrt{1+p^2}}, \qquad \sin v = \frac{1}{\sqrt{1+p^2}};$$

hence, combining these with the expressions for r, we have

$$\alpha = x - \frac{p}{q}(1+p^2), \qquad \beta = y + \frac{1}{q}(1+p^2);$$

or, substituting for p and q the quantities they denote,

$$\alpha = x - \frac{dy}{dx} \cdot \frac{dx^2+dy^2}{d^2y}, \qquad \beta = y + \frac{dx^2+dy^2}{d^2y}.$$

In these formulæ, and in the second and third for the radius of curvature, x is regarded as the independent variable, and y as a function of x.

80. From the way in which a curve may be generated by an evolute, we have a method of finding any number of curves which may be rectified, that is, whose length may be assigned in algebraic terms; for PH, the radius of the curvature, is the sum of the straight line CE, and the arc EH of the evolute. Now we can form innumerable curves whose radius of curvature will be known, therefore, corresponding to every curve whose radius of curvature can be found and expressed in algebraic terms, there is a curve which can be exactly rectified.

81. We shall now give examples of the application of the formulæ.

Ex. 1. Let the curve be a parabola, of which AC is the axis: let c denote the parameter, and let AQ $= x$, and PQ $= y$, be the co-ordinates of P, any point in the curve. Let CH be the evolute, and let AK $= \alpha$, HK $= \beta$, be the co-ordinates of H, the centre of curvature at P, the radius of curvature being PH $= r$.

By the nature of the curve, $y^2 = cx$, therefore,

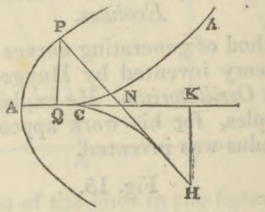
$$\frac{dy}{dx} = p = \frac{c}{2y}; \; 1+p^2 = \frac{c^2+4y^2}{4y^2} = \frac{c+4x}{4x};$$

$$\frac{d^2y}{dx^2} = \frac{dp}{dx} = q = -\frac{c}{2}\frac{dy}{dx} \cdot \frac{1}{y^2} = -\frac{c^2}{4y^3};$$

$$r = -\frac{(1+p^2)^{\frac{3}{2}}}{q} = \frac{(c^2+4y^2)^{\frac{3}{2}}}{2c^2} = \frac{(c^2+4cx)^{\frac{3}{2}}}{2c^2}$$

$$= \tfrac{1}{2}\sqrt{\frac{(c+4x)^3}{c}}.$$

Fig. 16.



This is the expression for the radius of curvature by formula (2). If we put the normal PN $= s$, we have, by formula (3) (art. 78),

$$r = -\frac{s^3}{qy^3} = \frac{4s^3}{c^2} \cdot = \frac{s^3}{(\frac{1}{2}c)^2} = \frac{(\text{normal})^3}{(\text{semipar.})^2}.$$

Next, to find the evolute, we have

$$\alpha = x - \frac{p}{q}(1+p^2) = x + \frac{4x+c}{2} = 3x + \tfrac{1}{2}c;$$

$$\beta = y + \frac{1+p^2}{q} = y - \frac{c^2+4y^2}{c^2}y = \frac{-4y^3}{c^2}.$$

$$\text{Hence } x = \tfrac{1}{3}(\alpha - \tfrac{1}{2}c), \;\; y = -\left(\frac{c^2\beta}{4}\right)^{\frac{1}{3}};$$

and since, by the nature of the parabola, $cx = y^2$; therefore the equation of the evolute is

$$\beta^2 = \frac{16}{27c^2}\left(\alpha - \frac{c}{2}\right)^3;$$

Take AC $= \frac{1}{2}c$, then C is a given point; and CK $= \alpha - \frac{1}{2}c$. Put CK $= x'$; HK $= \beta = -y'$, and the equation of the involute becomes

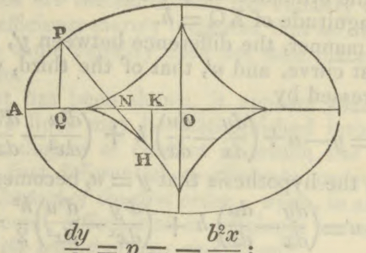
$$y'^2 = \frac{16}{27c}x'^3.$$

Hence it appears that the evolute is the semicubical parabola. This is the first curve that was rectified by the infinitesimal calculus.

Ex. 2. Let the curve be an ellipse, of which OA $= a$ is the semitransverse axis, and OB $= b$ the semiconjugate. Let $e = \sqrt{a^2 - b^2}$ be the eccentricity, and, assuming the centre as the origin of co-ordinates, let OQ $= x$, PQ $= y$, HP, the radius of curvature at P, $= r$.

The equation of the curve is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$; or $b^2x^2 + a^2y^2 = a^2b^2$: Hence

Fig. 17.



$$\frac{dy}{dx} = p = -\frac{b^2x}{a^2y};$$

$$1+p^2 = \frac{b^2}{a^2}\cdot\frac{a^4-(a^2-b^2)\,x^2}{a^2y^2} = \frac{b^2}{a^2}\cdot\frac{a^4-e^2x^2}{a^2y^2}$$

$$= \frac{b^4+(a^2-b^2)\,y^2}{a^2y^2} = \frac{b^4-e^2y^2}{a^2y^2}.$$

$$\frac{d^2y}{dx^2} = \frac{dp}{dx} = q = -\frac{b^2}{a^2y} + \frac{b^2x}{a^2y^2}\cdot\frac{dy}{dx} = -\frac{b^4}{a^2y^3};$$

$$\frac{(1+p^2)^{\frac{3}{2}}}{q} = \frac{-1}{a^4b}(a^4-e^2x^2)^{\frac{3}{2}} = \frac{-1}{ab^4}(b^4-e^2y^2)^{\frac{3}{2}}.$$

Hence the radius of curvature

$$r = \frac{1}{a^4b}(a^4-e^2x^2)^{\frac{3}{2}} = \frac{1}{ab^4}(b^4-e^2y^2)^{\frac{3}{2}}$$

$$= \frac{1}{a^4b^4}(a^4y^2+b^4x^2)^{\frac{3}{2}}.$$

The formula $r = -\frac{s^3}{y^3q}$ (where $s =$ the normal PN) gives this other value,

$$r = \frac{a^2}{b^4}s^3.$$

Now $\frac{b^2}{a}$ is half the parameter of the transverse axis;

therefore $r = \frac{(\text{normal})^3}{(\frac{1}{2}\text{ paramer})^2}$ ....(2)

To find the equation of the evolute, let H be any point in the curve; $OK = \alpha$, and $HK = \beta$, the co-ordinates. The values of p, $1+p^2$, and q, being substituted in the formula (art. 79), we have

$$\alpha = x - \frac{b^2x}{a^2y}\cdot\frac{a^2y^3}{b^4}\cdot\frac{b^2}{a^2}\cdot\frac{a^4-e^2x}{a^2y^2} = \frac{e^2x^3}{a^4}:$$

$$\beta = y - \frac{a^2y^3}{b^4}\cdot\frac{b^4-e^2y^2}{a^2y^2} = \frac{e^2y^3}{b^4}.$$

Let us exchange α and β for x' and y', and we have

$$\frac{x^2}{a^2} = \left(\frac{ax'}{e^2}\right)^{\frac{2}{3}};\quad \frac{y^2}{b^2} = \left(\frac{by'}{e^2}\right)^{\frac{2}{3}}.$$

Observing now that in the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, we have for the equation of the evolute

$$\left(\frac{ax'}{e^2}\right)^{\frac{2}{3}} + \left(\frac{by'}{e^2}\right)^{\frac{2}{3}} = 1;\ \text{or}\ (ax')^{\frac{2}{3}} + (by')^{\frac{2}{3}} = (a^2-b^2)^{\frac{2}{3}}.$$

The form of this equation is remarkable from its analogy to that of the ellipse itself. The curve has the form shown in figure 17.

Ex. 3. Let the curve be the cycloid; of which let AA′ be the base, BC the axis, BDC a circle whose diameter is BC. From P any point in the curve, draw PDE perpendicular to the axis, meeting the circle in D; draw PQ perpendicular to the base, and let PH be the radius of curvature.

Since all cycloids are similar figures, we may make the radius of the generating circle = 1; let CQ = PE = x, PQ = CE = y, the arc BD = v.

By the nature of the cycloid (art. 66, ex. 4),

$$x = v + \sin v,\quad y = 1 - \cos v,$$

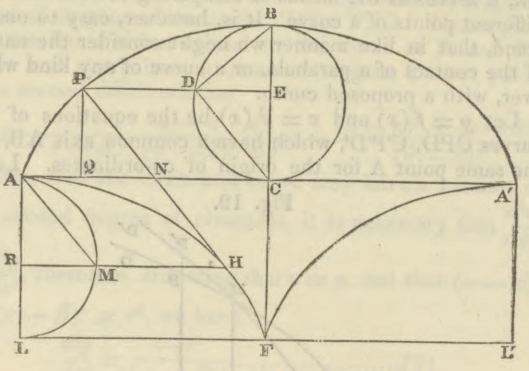
therefore $dx = dv\,(1+\cos v)$, $dy = dv \sin v$,

$$\frac{dy}{dx} = p = \frac{\sin v}{1+\cos v};\ 1+p^2 = \frac{2}{1+\cos v},\ dp = \frac{dv}{1+\cos v};$$

$$\frac{d^2y}{dx^2} = \frac{dp}{dx} = q = \frac{1}{(1+\cos v)^2},$$

Hence r, the rad. of cur. $= -\frac{(1+p^2)^{\frac{3}{2}}}{q} = \sqrt{8\,(1+\cos v)}.$

Fig. 18.



Draw the chord CD, and because

$1 + \cos v = 2\cos^2 \frac{1}{2}v$ (ALGEBRA, 249) $= 2\sin^2 \frac{1}{2}$ arc CD
$= \frac{1}{2}$ chord² CD.

Therefore, PH = r = 2 chord CD.

It was shown (art. 66) that a tangent at P is parallel to BD, the chord of the supplement of CD; therefore PH, which is perpendicular to the tangent, is parallel to the chord CD; it is therefore determined in position and magnitude for any given point in the curve.

The evolute AHF may be found by the general formula (art. 79), or otherwise from the expression for PH, the radius of curvature, thus:

Draw AL perpendicular to AC, and equal to BC, but on the opposite side of AC; describe the semicircle AML, and draw HMR perpendicular to AL, cutting the semicircle in M; let PH meet AC in N.

Because CA = semicircle CDB, and CN = DP = arc BD, therefore AN = arc CD. But because PH = 2CD = 2PN; and therefore PN = NH; the parallels PE, HR are equally distant from CA; and hence CE = RA, and arc CD = arc AM and chord CD = chord AM, also angle DCA = angle CAM. Now CD = PN = NH: therefore AM = NH; but AM is parallel to NH; therefore MH = AN = arc CD = arc AM; and HR = arc AM + sin MR; thus it appears that H is a point in a semicycloid having the same base as the cycloid ABA′. Indeed LAF is just the semicycloidal space CBA′ transferred to the position AHF, the point B being placed at A, and A′ at F. If the other semicycloidal space AB be transferred to the position FA′L′, the arc APB in the position FA′ will form another branch of the evolute, exactly similar to FA, but turned the contrary way.

From what has been found it appears, that if the semicycloids FLA, FL′A′ were placed in a vertical plane, with the point F uppermost, and the semi-bases FL, FL′ in a horizontal line; and if a weight were suspended from F by a thread equal in length to FB, and made to vibrate in that plane, like a pendulum; the weight would manifestly vibrate in an arc of a cycloid. This elegant property of the curve was discovered by Huygens, who also found that the vibrations would be isochronal, that is, performed in equal times. This is an important proposition in dynamics.

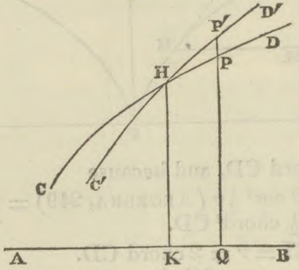
Contact of Curves.

82. The ancient geometers paid particular attention to the contact of straight lines, with the few curve lines which they considered. Apollonius even touched on the contact of circles and the conic sections; for he treated of the shortest line that can be drawn from a given point in the axis to the curve. It is only, however, since the invention of the differential calculus that this branch of geometry has been carried to any considerable extent.

83. The curvature of a circle being the same throughout, it serves as the means of comparing the curvature in different points of a curve. It is, however, easy to understand, that in like manner we might consider the nature of the contact of a parabola, or a curve of any kind whatever, with a proposed curve.

Let $y=f(x)$ and $v=\text{F}(x)$ be the equations of two curves CPD, C′P′D′, which have a common axis AB, and the same point A for the origin of co-ordinates. Let x be a common absciss, and y the corresponding ordinate of any point in the curve CD; also v, the like ordinate in the curve C′D′. Suppose now that when x becomes $x+h$, y becomes y', and v becomes v'; by Taylor's theorem,

Fig. 19.



$$y'=y+\frac{dy}{dx}h+\frac{d^2y}{dx^2}\,\frac{h^2}{1\,.\,2}+\&c.$$

$$v'=v+\frac{dv}{dx}h+\frac{d^2v}{dx^2}\,\frac{h^2}{1.2}+\&c.$$

Suppose now the curves to have a common point H, at which $y=v$; then, *If the curves be such that* $\frac{\text{dy}}{\text{dx}}=\frac{\text{dv}}{\text{dx}}$, *their contact at* P *will be of such a nature, that no third curve can pass between them at that point, unless it has a like property.*

Let HK $=y=v$, KQ $=h$, PQ $=y'$, P′Q $=v'$. Also, let $u=$ HK be the ordinate of a third curve that passes through H, and u' its value, corresponding to AQ $=x+h$, then

$$u'=u+\frac{du}{dx}h+\frac{d^2u}{dx^2}\,\frac{h^2}{1\,.\,2}+\&c.$$

We are to prove it to be impossible for the third curve, in leaving the point H, to pass between the arcs HP and HP′, unless $\frac{du}{dx}=\frac{dy}{dx}=\frac{dv}{dx}$. For suppose it possible, then, because in general

$$\text{PP}'=y'-v'=y-v+\left(\frac{dy}{dx}-\frac{dv}{dx}\right)h+\left(\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}\right)\frac{h^2}{2}+\&c.$$

and, because at the point H, $y=v$; and, in this particular case, $\frac{dy}{dx}=\frac{dv}{dx}$, we have

$$y'-v'=\left(\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}\right)\frac{h^2}{2}+\left(\frac{d^3y}{dx^3}-\frac{d^3v}{dx^3}\right)\frac{h^3}{6}+\&c.$$

This is the general expression for P′P′, the difference between the ordinates of the curves CD, C′D′, whatever be the magnitude of KQ $=h$.

In like manner, the difference between y', the ordinate of the first curve, and u', that of the third, will be generally expressed by

$$y'-u'=y-u+\left(\frac{dy}{dx}-\frac{du}{dx}\right)h+\left(\frac{d^2u}{dx^2}-\frac{d^2u}{dx^2}\right)\frac{h^2}{2}+\&c.$$

which, on the hypothesis that $y=u$, becomes

$$y'-u'=\left(\frac{dy}{dx}-\frac{du}{dx}\right)h+\left(\frac{d^2y}{dx^2}-\frac{d^2u}{dx^2}\right)\frac{h^2}{2}+\&c.$$

Now, if it were possible that the third curve, in leaving the common point H, could pass between the other two, we should, to a certain extent from the point H, have $y'-v'$ greater than $y'-u'$, that is, after dividing the expressions for $y'-v'$ and $y'-u'$ by h,

$$\left(\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}\right)\frac{h}{2}+\left(\frac{d^3y}{dx^3}-\frac{d^3v}{dx^3}\right)\frac{h^2}{6}+\&c.$$
$$>\frac{dy}{dx}-\frac{du}{dx}+\left(\frac{d^2y}{dx^2}-\frac{d^2u}{dx^2}\right)h+\&c.$$

And this equation ought to hold true, however small the line KQ $=h$ be taken. But h may be taken so small, that all the terms in the expression for $y'-v'$ shall be less than any assignable quantity, while those of $y'-u'$ continually approach to $\frac{dy}{dx}-\frac{du}{dx}$ as a limit, which by hypothesis is not equal to zero. Now these two conclusions are incompatible with each other; therefore it is impossible that the third curve can pass through the point P between the other two, when $\frac{dy}{dx}$ is not equal to $\frac{du}{dx}$.

If, however, $\frac{dy}{dx}=\frac{du}{dx}$, then the third curve may pass between the other two; for it will only be necessary that

$$\frac{d^2y}{dx^2}-\frac{d^2v}{dx^2}>\frac{d^2y}{dx^2}-\frac{d^2u}{dx^2},\ \text{that is,}\ \frac{d^2u}{dx^2}>\frac{d^2v}{dx^2},$$

which is evidently possible.

84. Again, if there be two curves whose equations are $y=f(x)$, $v=\text{F}(x)$, and which have a common ordinate $y=v$, and if they be such, that

$$\frac{dy}{dx}=\frac{dv}{dx},\quad \frac{d^2y}{dx^2}=\frac{d^2v}{dx^2};$$

then no third curve of which the equation is $u=\varphi(x)$, and which has a common ordinate with the other two, can pass between them, unless at the same time

$$\frac{dy}{dx}=\frac{du}{dx},\quad \frac{d^2y}{dx^2}=\frac{d^2u}{dx^2}.$$

This proposition is proved exactly in the same way as that in last article, by means of Taylor's theorem. These are particular cases of a general proposition relating to the contact of curves which may be stated thus: If two curves have a common absciss and ordinate, and if the differential co-efficients of the first order of the ordinates be equal, no third curve passing through their intersection can go between them, unless the differential co-efficient of its ordinate, corresponding to the same absciss, be equal to the differential co-efficients of their ordinates. And if, besides their first differential co-efficients, their second differential co-efficients be equal, then no third curve passing through their intersection can go between them, unless the first and second differential co-efficients of its ordinate be equal to the first and second differential co-efficients of the two curves, and so on to differential co-efficients of all orders.

In fact, the two curves meet only in the point in which their ordinates are the same, and the equality of the differential co-efficients merely indicates that no other curve in which the same equality does not take place can pass between them.

From what has been shown, it appears that the contacts of curve lines may be distinguished into different orders. The degree of contact in which the ordinates and also the first differential co-efficients are equal, may be called a *Contact of the first order;* when, in addition to these, the second differential co-efficients are equal, it is a *Contact of the second order;* and so on.

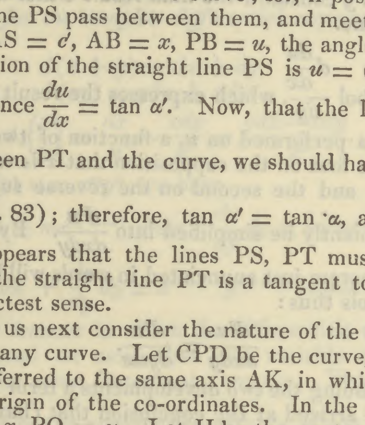
85. In illustration of this theory of contacts, let us consider the nature of the contact of any curve HPK (see fig. 6), with a straight line PT. Let A be the common origin of the co-ordinates. In the curve, let AB $= x$, PB $= y$. Its nature will be expressed by an equation $y = f(x)$. In the straight line, let TA $= c$, AB $= x$, PB $= v$, angle PTB $= \alpha$; the equation of the straight line is $v = (c + x) \tan \alpha$. The hypothesis that the curve and straight line have a common point, gives $y = v$; and the equation of the straight line, considering that c and α must be regarded as constants, gives $\frac{dv}{dx} = \tan \alpha$; now, by our theory, $\frac{dy}{dx} = \frac{dv}{dx}$, therefore $\frac{dy}{dx} = \tan \alpha$. This result coincides with what was found in art. 66; and it gives the sub-tangent

$$\mathrm{BT} = \frac{y}{\tan \alpha} = \frac{dx}{dy}\, y.$$

It is impossible that any straight line can pass between the straight line PT and the curve; for, if possible, let the straight line PS pass between them, and meet the axis in S. Put AS $= c'$, AB $= x$, PB $= u$, the angle PSB $= \alpha'$. The equation of the straight line PS is $u = (c' + x) \tan \alpha'$; and hence $\frac{du}{dx} = \tan \alpha'$. Now, that the line PS may pass between PT and the curve, we should have $\frac{du}{dx} = \frac{dv}{dx} = \frac{dy}{dx}$ (art. 83); therefore, $\tan \alpha' = \tan \alpha$, and $\alpha' = \alpha$; thus it appears that the lines PS, PT must coincide; therefore the straight line PT is a tangent to the curve, in the strictest sense.

86. Let us next consider the nature of the contact of a circle and any curve. Let CPD be the curve, and C′PD′ a circle referred to the same axis AK, in which A is the common origin of the co-ordinates. In the curve CPD let AQ $= x$, PQ $= y$. Let H be the centre of the circle; draw the radius PH, and produce it to meet the axis in N, and draw HI, HK perpendicular to PQ and AQ. Put AQ $= x$, PQ $= v$, these being co-ordinates of P any point in the circumference of the circle; and put AK $= \alpha$, HK $= \beta$, the co-ordinates of its centre; and PH $= r$ its radius.

Fig. 20.



Direct Method.

The equation of the curve CPD may be expressed generally by $y = f(x)$. And, since IH $= \alpha - x$, PI $= v - \beta$, and PH $= r$, the equation of the circle will be

$$(\alpha - x)^2 + (v - \beta)^2 = r^2 \ldots\ldots\ldots\ldots\ldots (1)$$

A contact of the first degree requires that $\frac{dy}{dx} = \frac{dv}{dx}$. Now, observing that α, β, and r must be considered as constants, we have $\frac{dv}{dx} = \frac{\alpha - x}{v - \beta}$, hence and because $y = v$,

$$\frac{dy}{dx} = \frac{\alpha - x}{y - \beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The second side of this formula expresses the trigonometrical tangent of the angle PHI or PNQ. Hence (art. 65) the line PN is a normal to the curve at P, and the circle and curve have a common tangent at that point. By a second differentiation

$$\frac{d^2v}{dx^2} = -\frac{1}{v - \beta} - \frac{\alpha - x}{(v - \beta)^2} \cdot \frac{dv}{dx} = -\frac{(\alpha - x)^2 + (v - \beta)^2}{(v - \beta)^3}.$$

Now, that the circle and curve may have a contact of the second degree of closeness, it is necessary that $\frac{d^2v}{dx^2} = \frac{d^2y}{dx^2}$, therefore, observing that $v = y$, and that $(\alpha - x)^2 + (v - \beta)^2 = r^2$, we have

$$\frac{d^2y}{dx^2} = \frac{-r^2}{(y - \beta)^3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The three equations (1), (2), (3) serve to determine r, the radius of the circle, and α, β the co-ordinates of its centre. From the first and second we get

$$\alpha - x = \frac{r\,dy}{(dx^2 + dy^2)^{\frac{1}{2}}}; \quad y - \beta = \frac{r\,dx}{(dx^2 + dy^2)^{\frac{1}{2}}};$$

and from these, and equation (3), we get

$$r = -\frac{(dx^2 + dy^2)^{\frac{3}{2}}}{dx\,d^2y};$$

$$\alpha = x - \frac{dy}{dx} \cdot \frac{dx^2 + dy^2}{d^2y}; \quad \beta = y + \frac{dx^2 + dy^2}{d^2y}.$$

These expressions for α, β, and r determine the position and magnitude of the circle; they are manifestly identical with the radius of the circle of equal curvature, and the co-ordinates of its centre formerly found (art. 78 and 79). Hence we conclude, that the circle of equal curvature with a curve in any point, determined by the theory of evolutes, is identical with a circle, having with the curve a contact of the second order.

And since it appears that only one circle can have with a curve a contact of the second order, and that no circle can pass between that circle and the curve, therefore the same must be true of the circle of equal curvature, found by the theory of evolutes.

87. From what has been shown in regard to the degrees of contact of a straight line and circle with a curve, it appears that these depend on the number of constants which enter into the equation of the touching line. The equation of a straight line contains two constants, and it admits of one order of contact only. The equation of a circle has three constants, and it admits of a contact of the second order. It is easy to see that the number of differential co-efficients that can be made equal in the two curves will always be one less than the number of constants in the touching curve. The equation of a parabola is $y = \alpha + \beta x + \gamma x^2$. This and the differential equations which may be deduced from it serve to determine the three constants α, β, γ, and thence the parabola of equal curvature; but since there are only two differential co-efficients, the parabola can have a contact of the first and

also of the second order with any curve, but no higher order of contact. A cubic parabola, whose equation is $y = \alpha + \beta x + \lambda x^2 + \delta x^3$, may, however, have a contact of the third order, because it involves four constants, and so on.

Development and Differentiation of Functions containing two Variables.

88. Let u be a function of two independent variables, x and y; for example, $u = ax^2 + bxy + cy^2$, and in general $u = f(x, y)$. Suppose now that x changes its value, and becomes $x + h$, and that y becomes $y + k$, so that u' being the new value of the function, $u' = f(x+h, y+k)$. It is proposed to expand u' into a series of terms proceeding by the integer powers of h and k. In particular cases the method of proceeding is obvious; a general formula may be found by Taylor's theorem as follows.

It is easy to see that the result will be the same whether we substitute at once $x + h$ for x, and $y + k$ for y, in the function u, and then expand it; or, otherwise, first substitute $x + h$, then expand the function, according to the powers of h, and in this first result put $y + k$ for y, and afterwards expand it into terms proceeding by the powers of k; or we may reverse this process, beginning with the expansion according to the powers of k, and ending with that proceeding by the powers of h.

Resuming the function $u = f(x, y)$; when x becomes $x + h$, we have by Taylor's theorem $f(x + h, y) =$

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{1.2} + \frac{d^3u}{dx^3}\frac{h^3}{1.2.3} + \&c.$$

the differentials being taken upon the supposition that x is variable, and y a constant. And in this series y is contained only in the function u, and the differential co-efficients $\frac{du}{dx}, \frac{d^2u}{dx^2}$, &c.

Suppose now that y becomes $y + k$, then, in the series, the function u becomes

$$u + \frac{du}{dy}k + \frac{d^2u}{dy^2}\frac{k^2}{1.2} + \frac{d^3u}{dy^2}\frac{k^3}{1.2.3} + \&c.;$$

the function $\frac{du}{dx}$ becomes

$$\frac{du}{dx} + \frac{d\frac{du}{dx}}{dy}k + \frac{d^2\frac{du}{dx}}{dy^2}\frac{k^2}{1.2} + \frac{d^3\frac{du}{dx}}{dy^3}\frac{k^3}{1.2.3} + \&c.;$$

the function $\frac{d^2u}{dx^2}$ becomes

$$\frac{d^2u}{dx^2} + \frac{d\frac{d^2u}{dx^2}}{dy}k + \frac{d^2\frac{d^2u}{dx^2}}{dy^2}\frac{k^2}{1.2} + \frac{d^3\frac{d^2u}{dx^2}}{dy^3}\frac{k^3}{1.2.3} + \&c.;$$

the function $\frac{d^3u}{dx^3}$ becomes

$$\frac{d^3u}{dx^3} + \frac{d\frac{d^3u}{dx^3}}{dy}k + \frac{d^2\frac{d^3u}{dx^3}}{dy^2}\frac{k^2}{1.2} + \frac{d^3\frac{d^3u}{dx^3}}{dy^3}\frac{k^3}{1.2.3} + \&c.;$$

and in the differentiation of the functions $u, \frac{du}{dx}, \frac{d^2u}{dx^2}$, &c., y is taken as the variable, and x as a constant. By making the proper substitutions, we have $f(x + h, y + k)$ expressed by the series

$$u + \frac{du}{dy}k + \frac{d^2u}{dy^2}\frac{k^2}{1.2} + \&c.$$

$$+ \frac{du}{dx}h + \frac{d\frac{du}{dx}}{dy}hk + \&c.$$

$$+ \frac{d^2u}{dx^2}\frac{h^2}{1.2} + \&c.$$

$$+ \&c.$$

If the substitutions of $x + h$ for x, and $y + k$ for y, had been made in an inverse order, we would have had $f(y + k, x + h)$ equal to

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{1\cdot2} + \&c.$$

$$+ \frac{du}{dy}k + \frac{d^2\frac{du}{dy}}{dx}hk + \&c.$$

$$+ \frac{d^2u}{dy^2}\frac{k^2}{1\cdot2} + \&c.$$

The order in which the substitutions are made being arbitrary, the two developments of $f(x + h, y + k)$ must be identical, consequently the terms containing the same products of h and k must be equal. Thus, passing over the terms which are the same, we have

$$\frac{d\frac{du}{dx}}{dy} = \frac{d\frac{du}{dy}}{dx}.$$

89. This formula proves an important theorem in the calculus, namely, if a function u of two independent variables x and y be twice differentiated, first, on the hypothesis that x is variable and y constant, and then the result on the supposition that y is variable and x constant. And again, if the order of the differentiations be reversed, that is, if y be made variable and x constant, and then x variable and y constant, the final result either way will be the very same.

The symbol $\frac{d\frac{du}{dx}}{dy}$, which expresses the result of two differentiations performed on u, a function of two variables x and y (the first on the supposition that x is variable and y constant, and the second on the reverse supposition), may conveniently be simplified into $\frac{d^2u}{dxdy}$. By this notation the theorem just enunciated in words will be expressed in symbols thus:

$$\frac{d^2u}{dxdy} = \frac{d^2u}{dydx}.$$

By continuing the two developments a term farther, we would have arrived at the conclusion that (having regard to the notation just premised),

$$\frac{d^3u}{dxdydx} = \frac{d^3u}{dx^2dy} = \frac{d^3u}{dydx^2};$$

$$\text{and that } \frac{d^3u}{dxdy^2} = \frac{d^3u}{dy^2dx}, \&c.$$

Suppose, for example, that $u = x^3 y^5$, then

$$\frac{du}{dx} = 3\,x^2y^5, \qquad \frac{du}{dy} = 5\,x^3y^4,$$

$$\frac{d^2u}{dxdy} = 15\,x^2y^4, \quad \frac{du}{dydx} = 15\,x^2y^4,$$

$$\frac{d^3u}{dx^2dy} = 30\,xy^4, \quad \frac{d^3u}{dydx^2} = 30\,xy^4.$$

Adopting now the abbreviated notation, when $u = f(x, y)$, we have $f(x + h, y + k) =$

$$u + \frac{du}{dx}h + \frac{d^2u}{dx^2}\frac{h^2}{2} + \frac{d^3u}{dx^3}\frac{h^3}{2\,.\,3} + \&c.$$

$$+ \frac{du}{dy}k + \frac{d^2u}{dydx}hk + \frac{d^3u}{dydx^2}\frac{hk^2}{2} + \&c$$

$$+\frac{d^2u}{dy^2}\frac{k^2}{2}+\frac{d^3u}{dy^2dx}\frac{hk^2}{2}+\text{\&c.}$$

$$+\frac{d^3u}{dy^3}\frac{k^3}{2\,.\,3}+\text{\&c.}$$

This is the complete development of the function u.

90. Supposing u to be any function of x, and that x becomes $x+h$, by which u becomes $u+ph+qh^2+$&c., or (considering h as the *differential* of x) $u+pdx+qdx^2+$ &c. We have defined the *differential* of u to be the term pdx, viz. that which contains the simple power of h or dx, and called the function p, the *differential co-efficient*, representing it by $\frac{du}{dx}$. We may now extend these definitions to $f(x, y)$, a function of two variables, and changing h into dx and k into dy in the development of the function, we shall have

$$df(x, y)=du=\frac{du}{dx}dx+\frac{du}{dy}dy.$$

From this it appears that the *complete* differential of a function of two variables consists of two parts, viz. $\frac{du}{dx}dx$, or the differential taken on the supposition that x alone is variable, and $\frac{du}{dy}dy$, or the differential taken when y only is variable.

We may also apply to functions of two variables the rules which have been given (art. 10–23) for those which depend only on one; and for this purpose *we must differentiate the function first with respect to one of its variables, and then with respect to another; and take the sum of the results for the complete differential required.* By this rule

$$d(x+y)=dx+dy$$
$$d(xy)=ydx+xdy,$$
$$d\left(\frac{x}{y}\right)=\frac{dx}{y}-\frac{xdy}{y^2}=\frac{ydx-xdy}{y^2}.$$

Again, let $u=x^my^n$, we have

$$\frac{du}{dx}dx=mx^{m-1}y^ndx,\quad \frac{du}{dy}dy=nx^my^{n-1}dy,$$

$$du=\frac{du}{dx}dx+\frac{du}{dy}dy=x^{m-1}y^{n-1}(mydx+nxdy).$$

91. The manner in which the differentials of functions which depend on more than one variable are written, gives rise to some important remarks. The expression $\frac{du}{dx}dx$ must not be confounded with du, which it might be if u contained only the variable x; the symbol $\frac{du}{dx}$ has in this case a particular meaning, and denotes the differential co-efficient taken on the hypothesis of x only being variable; or it is the quotient of the first term of the development of the difference taken on that supposition divided by the increment dx; and $\frac{du}{dy}dy$ signifies the same with respect to y.

The quantities $\frac{du}{dx}, \frac{du}{dy}$ are commonly called *partial differences* of the first order of the function u, and generally $\frac{d^{m+n}u}{dx^mdy^n}$ represents one of those of the order $m+n$, which arises by differentiating m times in respect of x, and n times in respect of y.

A function of a single variable has only one differential co-efficient of any order; but a function of two variables has two differential co-efficients for the first order, three for the second, &c. These may be deduced from the two first, beginning with

$$du=\frac{du}{dx}dx+\frac{du}{dy}dy;$$

then, taking the differentials of $\frac{du}{dx}$ and $\frac{du}{dy}$, which must be treated as functions of two variables, we have

$$d\frac{du}{dx}=\frac{d^2u}{dx^2}dx+\frac{d^2u}{dydx}dy,$$

$$d\frac{du}{dy}=\frac{d^2u}{dxdy}dx+\frac{d^2u}{dy^2}dy;$$

and since the second differential is nothing more than the differential of the first,

$$d^2u=\frac{d^2u}{dx^2}dx^2+2\frac{d^2u}{dxdy}dxdy+\frac{d^2u}{dy^2}dy^2.$$

Here dx and dy are considered as constant quantities, and the differential co-efficients whose denominators contain only the products of dx and dy differently arranged, are considered as identical. By a repetition of this process, an expression may be found for the third differential co-efficient of the function u, and so on to any differential.

92. What has been explained in respect of a function of two independent variables, will apply to a function of any number; thus, if $u=f(t, x, y, z)$, then,

$$du=\frac{du}{dt}dt+\frac{du}{dx}dx+\frac{du}{dy}dy+\frac{du}{dz}dz,$$

where the symbols

$$\frac{du}{dt}, \frac{du}{dx}, \frac{du}{dy}, \frac{du}{dz},$$

denote the differential co-efficients of the function u taken on the supposition that t or x or y or z alone varies.

This notation owes its origin to Fontaine. Euler feared that the differential co-efficient $\frac{du}{dx}$ might be confounded with the ratio of the complete differential du to the differential dx, which is equivalent to

$$\frac{\frac{du}{dt}dt+\frac{du}{dx}dx+\frac{du}{dy}dy+\frac{dz}{dz}dz}{dx},$$

he therefore denoted this ratio by $\frac{du}{dx}$, whilst he expresses the differential co-efficient found by supposing x alone variable by $\left(\frac{du}{dx}\right)$. The nature of the subject, however, in general shows which of the two is intended, and renders this distinction superfluous.

Of Changing the Independent Variable.

93. Supposing y to be any function of x, we have estimated every change in the magnitude y by that of the value of x, which has been supposed to vary in any way whatever. It is, however, sometimes convenient to reverse the hypothesis, and consider x as a function of y. We are now to investigate general rules, by which we may pass from the differentials of y, regarded as a function of x, to those of x considered as a function of y.

Let $y=f(x)$, and let us suppose that when x becomes $x+h$, y becomes $y+k$. By Taylor's theorem,

$$k=\frac{dy}{dx}h+\frac{d^2y}{dx^2}\frac{h^2}{2}+\frac{d^3y}{dx^3}\frac{h^3}{2\,.\,3}+\text{\&c.}\ldots\ldots\ldots\ldots\ldots(1)$$

On the reverse hypothesis, supposing $x = \mathrm{F}(y)$ a function of y, then, similarly,

$$h = \frac{dx}{dy}k + \frac{d^2x}{dy^2}\frac{k^2}{2} + \frac{d^3x}{dy^3}\frac{k^3}{2 \, . \, 3} + \&\text{c.} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Let the value of k, as given by the first equation, be substituted in the second; and, in order to abridge, let us put $\frac{dy}{dx} = y'$, $\frac{d^2y}{dx^2} = y''$, &c.

also $\frac{dx}{dy} = x'$, $\frac{d^2x}{dy^2} = x''$, &c.; then we have

$$h = x'\left(y'h + y''\frac{h^2}{2} + y'''\frac{h^3}{2 \, . \, 3} + \&\text{c.}\right)$$

$$+ \frac{x''}{2}\left(y'h + y''\frac{h^2}{2} + y''\frac{h^3}{2 \, . \, 3} + \&\text{c.}\right)^2 + \&\text{c.}$$

Hence, by actually involving the series to the second, third, powers, &c. and bringing into one term like powers of h, we find

$$0 = (x'y' - 1)\,h + (x'y'' + x''y'^2)\frac{h^2}{2}$$

$$+ (x'y''' + 3x''y'y'' + x'''y')\frac{h^3}{3} + \&\text{c.}$$

Now, that this equation may be satisfied, the co-efficients of the powers of h must be each $= 0$; thus,

$$x'y' - 1 = 0, \quad x'y'' + x''y'^2 = 0,$$
$$x'y''' + 3x''y'y'' + x'''y' = 0, \ \&\text{c.}$$

These equations give us

$$y' = \frac{1}{x'}, \quad y'' = -\frac{x''}{x'^3}, \quad y''' = \frac{3x''^2}{x'^5} - \frac{x'''}{x'^4},$$

$$y^{\text{IV}} = \frac{15x''^3}{x'^7} + \frac{10x''x'''}{x'^6} - \frac{x^{\text{IV}}}{x'^5}, \ \&\text{c.}$$

Reversely, we have

$$x' = \frac{1}{y'}, \quad x'' = -\frac{y''}{y'^3}, \quad x''' = \frac{3y''^2}{y'^5} - \frac{y'''}{y'^4},$$

$$x^{\text{IV}} = \frac{15y''^3}{y'^7} + \frac{10y''y'''}{y'^6} - \frac{y^{\text{IV}}}{y'^5}, \ \&\text{c.}$$

As an application of these formulæ, we may transform the expression for the radius of curvature found (art. 78), on the hypothesis that y is a function of x, into another in which x is a function of y. Employing the notation of last article,

$$r = -\frac{(1 + y'^2)^{\frac{3}{2}}}{y''}.$$

Now by the formulæ $y' = \frac{1}{x'}$, and $y'' = -\frac{x''}{x'^3}$: this substitution being made, we obtain

$$r = \frac{(x'^2 + 1)^{\frac{3}{2}}}{x''} = \frac{(dx^2 + dy^2)^{\frac{3}{2}}}{dyd^2x}.$$

94. Instead of supposing that one of the two variables x, y, is a function of the other, it is sometimes convenient to regard both as functions of a third quantity. Thus, in geometry, supposing x and y to be the co-ordinates of a curve, we may consider the one as a function of the other; or we may consider both as functions of the angle which a tangent makes with the axis, which angle is then the independent variable. Or x and y denoting the co-ordinates of the path of a projectile, both may be considered as functions of t, the time of the motion.

Suppose that when t becomes $t + i$, x becomes $x + h$, and that y becomes $y + k$; to abridge, put x', x'', &c. for $\frac{dx}{dt}$, $\frac{d^2x}{dt^2}$, &c.; also y', y'', &c. for $\frac{dy}{dt}$, $\frac{d^2y}{dt^2}$, &c. and (y'), (y''), &c. for $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$, &c.

By Taylor's theorem,

$$y = f(x) \text{ gives } k = (y')\,h + (y'')\frac{h^2}{2} + \&\text{c.} \ldots\ldots (1)$$

$$y = \mathrm{F}(t) \text{ gives } k = y'i + y''\frac{i^2}{2} + \&\text{c.} \ldots\ldots\ldots\ldots\ldots (2)$$

$$x = \varphi(t) \text{ gives } h = x'i + x''\frac{i^2}{2} + \&\text{c.} \ldots\ldots\ldots\ldots\ldots (3)$$

The three increments k, h, i are generated together, therefore these equations must all hold true at the same time. Let the value of h, found from the third equation, be substituted in the first, then, putting the two values of k equal, we have

$$(y')\left\{x'i + x''\frac{i^2}{2} + \&\text{c.}\right\}$$

$$+ (y'')\left\{x'i + x''\frac{i^2}{2} + \&\text{c.}\right\}^2 + \&\text{c.}$$

$$= y'i + y''\frac{i^2}{2} + \&\text{c.}$$

Hence, by involution, and making the co-efficients of like powers of i equal to zero, as usual, we find

$$x'(y') = y', \quad x''(y') + x'^2(y'') = y'', \ \&\text{c.}$$

$$\text{therefore } (y') = \frac{y'}{x'} \qquad (y'') = \frac{y'' - x''(y')}{x'^2}, \ \&\text{c.}$$

As an example, let us take the formula for the radius of curvature, which, by the notation just premised, will be

$$r = -\frac{\{1 + (y')^2\}^{\frac{3}{2}}}{(y'')^2}.$$

By substituting for (y') and (y'') their values, it becomes

$$r = -\frac{(x'^2 + y'^2)^{\frac{3}{2}}}{x'y'' - y'x''};$$

and hence, putting $\frac{dx}{dt}$ for x', $\frac{dy}{dt}$ for y', $\frac{d^2x}{dt^2}$ for x'', and $\frac{d^2y}{dt^2}$ for y'', we get

$$r = \frac{(dx^2 + dy^2)^{\frac{3}{2}}}{dyd^2x - dxd^2y}.$$

The independent variable t does not appear in the formula; nevertheless, in its application, we must keep in mind the hypothesis by which it was found.

Of the Method of Infinitesimals.

95. The ideas which we have of infinity may be embodied in this proposition: *A quantity is not infinite so long as it admits of augmentation.* If, therefore, in the quantity $x + a$, we suppose x to become infinite, then a must be suppressed, otherwise it would be supposed that x might be increased by the quantity a, which is contrary to the definition. To show the consistency of the proposition, let there be an equation

$$\frac{1}{a} + \frac{1}{x} = \mathrm{M} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

which being multiplied by the product ax, becomes

$$x + a = \mathrm{M}ax \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Suppose now that x increases until it becomes infinite; the fraction $\frac{1}{x}$, having reached its last degree of diminution, is reduced to 0, and therefore equation (1) becomes

$$\mathrm{M} = \frac{1}{a}, \text{ or } \mathrm{M}a = 1;$$

and this value being substituted in equation (2), it becomes $x+a=x$. This shows that when x is infinite, $x+a$ is reduced to x.

The quantity a, in respect of which x is infinite, is called an *infinitesimal* in respect of x.

Since we consider here only the ratios of quantities, the preceding demonstration holds good when x has a finite value, provided that a be infinitely small in respect of x. Thus, if we compare b, a finite quantity, with the fraction $\frac{b}{z}$, then, z being supposed to increase continually, $\frac{b}{z}$ will decrease, and may become smaller than any assignable quantity; and when z is infinite, the fraction is $=0$, so that, in comparison with b, it may be neglected.

The ratios of quantities are altogether independent of their absolute magnitude. The halves, or any like parts of quantities, have the same ratios as the wholes. The symbols we employ in our reasonings are not the representatives of absolute magnitudes, but of numbers, which have a reference to an unit; they therefore represent ratios only, and the absolute magnitudes of the terms of the ratios are never considered. The differentials of quantities are the ratios to which the ratios of the increments of the variables continually approach; these increments may have any magnitude whatever. Leibnitz supposed them to be infinitely small quantities. Upon this hypothesis a theory has been constructed, which, by following certain ascertained principles, has led to the discovery of the most recondite truths in geometry and physics.

96. The admission of infinitesimals into the mathematical sciences, necessarily leads to a succession of different orders of infinitesimals. In a circle the ratio of the diameter to the chord of an arc is the same as the ratio of the chord to the versed sine; therefore, if the chord be infinitely small in respect of the diameter, or an infinitesimal of the *first* order, the versed sine will be infinitely small in respect of the chord; and, consequently, in respect of the diameter, will be an infinitesimal of the *second* order. So also, in a series of continued proportionals, $1, x, x^2, x^3$, &c. of which the first term is finite, and the second, x, an infinitesimal of the first order, the third, x^2, will be of the second order, and the fourth, x^3, of the third, and so on. Upon the same principle, the product ab of two infinitesimals, a, b of the first order will be an infinitesimal of the second; for we may consider that $1:a=b:ab$, that is, ab is a fourth proportional to three quantities 1, a, and b, of which the first is finite. In like manner, the product of three infinitesimals of the first order, also the product of an infinitesimal of the first and of the second order, will be an infinitesimal of the third order.

97. When the infinitely small increments of quantities are once taken as their differentials, the different rules for differentiation are easily found.

Thus, if $u=xy$; then u, x, and y receiving the infinitely small augments du, dx, and dy, we have

$$u+du=(x+dx)(y+dy)=xy+xdy+ydx+dxdy;$$

and, taking from these equals the equals u and xy,

$$du=xdy+ydx+dxdy.$$

Now du, xdy, ydx are infinitesimals of the first order, and $dxdy$ is an infinitesimal of the second, therefore it is incomparably smaller, and in respect of the others ought to be rejected, so that we have simply

$$du=xdy+ydx.$$

98. In this theory a curve is considered as a polygon of an infinite number of sides, any one of which is the differential of the arc, therefore the differential of the arc will be the hypotenuse of a right-angled triangle, of which the sides are the differentials of the co-ordinates; and these being denoted by x and y, and the arc by z, we have $dz^2=dx^2+dy^2$. Proceeding on the same principles, if s denote the area of a curve, the increment of s or ds will be $ydx+\frac{1}{2}dxdy$; but the second part of this, viz. $\frac{1}{2}dxdy$, is a differential of the second order, and therefore infinitely less than ydx, which is of the first order, therefore we have simply $ds=ydx$, agreeing with the formula of art. 69.

In a circle, the infinitely small increments of the cosine, the sine, and the arc form a right-angled triangle similar to that formed by the sine, the cosine, and the radius, so that x being put for the arc, the radius being unity,

$1:\cos x=dx:d\sin x$, $1:\sin x=dx:-d\cos x$,
hence $d\sin x=dx\cos x$, and $d\cos x=-xdx$.

It is equally manifest, according to the infinitesimal theory, that the subtangent is a fourth proportional to dx (the differential of the absciss), dy (the differential of the ordinate), and y the ordinate; so that, as has been shown, art. 65,

$$\text{subtan}=\frac{\pm dy}{dx}y;$$

the positive sign being used if the absciss and ordinate increase together, otherwise the sign —.

The great facility which the theory of infinitesimals gives in the applications of the calculus to the higher geometry, and more especially to the doctrines of physics, is a high recommendation in its favour. Indeed, whatever view be taken of the subject, the mathematician will hardly be restrained from taking the shortest way he can find to the object he wishes to attain, and that is in general by the infinitesimal calculus. Accordingly we observe that M. Poisson, in the second edition of his *Traité de Mécanique*, distinctly premises that he will exclusively employ the method of *infiniment petits* throughout his work.

PART II.

INVERSE METHOD OF FLUXIONS, OR INTEGRAL CALCULUS.

99. The *inverse method of fluxions*, or *integral calculus*, treats of the analytic processes by which a function may be found, such, that being differentiated, it shall produce a given differential. This function has been called, by writers on fluxions, the *fluent* or *flowing quantity*; and by writers on the differential calculus, the *integral* of the proposed differential.

To find the integral of a differential is to *integrate* that differential; and the process by which the integral is found is called *integration*.

100. When an integral is proposed, its differential may always be found by general rules. There is however no direct rule by which we may return from the differential to the integral, except the obvious one of retracing the steps by which the differential has been deduced from the integral. When these are distinctly indicated, there is no difficulty; but in general the steps of calculation by which the differential might have been deduced from an integral are obliterated or unknown; or the differential may not have been a direct result of differentiation; and then there will be no traces to show how we may pass from it to the integral.

101. It is convenient to have a symbol by which the integral of a differential may be indicated without regard to its particular form: for this purpose the letter $\int$ (the initial letter of the word *sum*) is employed. Thus, the integral of the differential $\mathrm{X}dx$ is expressed by the symbol $\int \mathrm{X}dx$.

102. We have seen (art. 9) that in differentiating an expression of the form $\mathrm{X}\pm\mathrm{C}$, which is the sum or dif-

ference of a variable function and a constant quantity, the constant disappears; therefore, reversely, in taking the integral of any differential, the constant, C, must be added to make the integral complete. This indeterminate quantity has been called by early English writers the *correction* of the fluent or integral, but now it is generally called the *arbitrary constant.* It may be written either with the sign $+$ or $-$; its value is to be determined, as will appear hereafter, from the particular problem under consideration.

Integration of Rational Functions involving one Variable.

103. The general form of a differential of the first order of a function is Xdx, where X denotes any function of a single variable x. Now this function may have various forms, and may be rational or irrational.

The rational forms of the function may be

$$Ax^m + Bx^n + Cx^p + \&c. = U,$$

$$\frac{Ax^m + Bx^n + Cx^p + \&c.}{A'x^{m'} + B'x^{n'} + C'x^n + \&c.} = \frac{U}{V},$$

the first of which is integral and the second fractional.

Irrational functions have the form

$$UV^{\frac{m}{n}},$$

and transcendental functions,

$$f(U, \text{l. } U),\ f(U, \sin v), \&c.$$

104. The simplest case of a rational function is ax^n, the differential of which is $nax^{n-1}dx$; therefore, putting $m = n - 1$, so that $n = m + 1$, we have,

when $dy = ax^m dx$,

$$\text{then } y = \int ax^m dx = \frac{a}{m+1}\, x^{m+1} + C.$$

Hence this rule: *To integrate a differential of one term, such as* ax^n dx, *we must increase the exponent of the variable by an unit, and then divide by the new exponent and by* dx.

We may give the indeterminate constant C the form $-\frac{ab^{n+1}}{n+1}$, and then we shall have

$$\int ax^n dx = \frac{a(x^{n+1} - b^{n+1})}{n+1}.$$

This is the form the integral should have, if it has the property of vanishing in the particular case of $x = b$.

105. There is a particular case to which the general rule of last article will not immediately apply; it is that in which $n = -1$; in that case it gives

$$\int \frac{adx}{x} = \int ax^{-1} dx = \frac{a(x^0 - b^0)}{0} = \frac{1-1}{0} = \frac{0}{0}.$$

From this no conclusion can be drawn, and the integral has been said to *fail.* This, however, is only in appearance; for, putting $n+1 = m$, we have (art. 35)

$$x^m = 1 + (\text{l. } x)\, m + (\text{l. } x)^2 \frac{m^2}{1\cdot 2} + \&c.$$

$$b^m = 1 + (\text{l. } b)\, m + (\text{l. } b)^2 \frac{m^2}{1\cdot 2} + \&c.$$

$$x^m - b^m = \{\text{l. } x - \text{l. } b\}\, m + \{(\text{l. } x)^2 - (\text{l. } b)^2\} \frac{m^2}{1\cdot 2} + \&c.$$

$$\frac{x^m - b^m}{m} = \text{l. } x - \text{l. } b + \{ (\text{l. } x)^2 - (\text{l. } b)^2 \frac{m}{2} + \&c.$$

This, when $n+1 = m = 0$ and $n = -1$, gives

$$\int \frac{adx}{x} = a\{\text{l. } x - \text{l. } b\} = a \text{ l. } x + C.$$

This result coincides entirely with the expression for the differential of the logarithm of a number (art. 20).

106. By the rule of art. 104 it is evident that if

$$dy = ax^m dx + bx^n dx + cx^p dx,$$

$$\text{then, } y = \frac{ax^{m+1}}{m+1} + \frac{bx^{n+1}}{n+1} + \frac{cx^{p+1}}{p+1} + C.$$

This is true, however many terms there may be in the differential: the indeterminate constant C represents the aggregate of all the constants of the integrals of the several terms.

In general, since (art. 15),

$$d(u + v - z) = du + dv - dz,$$

$$\text{therefore } u + v - z = \int du + \int dv - \int dz;$$

and in general, P, Q, R, being any functions of x,

$$\int (Pdx + Qdx - Rdx) = \int Pdx + \int Qdx - \int Rdx.$$

107. It has been found that u and v being any functions of a variable, $d(uv) = udv + vdu$, therefore

$$\int udv = uv - \int vdu.$$

In like manner, from the differential of a fraction we find

$$\int u \frac{dv}{v^2} = -\frac{u}{v} + \int \frac{du}{v}.$$

Since $d(au) = adu$, we may conclude that

$$\int aXdx = a \int Xdx.$$

108. To integrate the differential

$$dy = (ax + b)^m dx,$$

we may expand the given power, and integrate the terms of the result separately; otherwise, make $z = ax + b$, then

$$x = \frac{z-b}{a},\quad dx = \frac{dz}{a}.$$

By substitution, we have now $dy = \frac{z^m dz}{a}$, and by integration,

$$y = \frac{z^{m+1}}{a(m+1)} + C = \frac{(ax + b)^{m+1}}{a(m+1)} + C.$$

The integral of $dy = (ax^n + b)^m\, x^{n-1}\, dx$ may be found in the same way, by putting $ax^n + b = z$; we thus get

$$y = \frac{(ax^n + b)^{m+1}}{na(m+1)} + C.$$

109. We shall next consider fractional functions, and begin with the simple case of $dy = \frac{Ax^m dx}{(ax+b)^n}$; making $z = ax + b$, we find

$$x = \frac{z-b}{a},\quad dx = \frac{dz}{a},$$

and consequently

$$dy = \frac{A(z-b)^m dz}{a^{m+1}\, z^n}.$$

By expanding $(z - b)^m$ into a series, then multiplying the terms by dz, and dividing by z^n, the differential will be transformed into a series of terms of the form $cz^p dz$, which may be integrated severally by the rule (art 104). As a particular example, let $m = 3$, $n = 2$, then

$$dy = \frac{A(z - b)^3 dz}{a^4 z^2}$$

$$= \frac{A}{a^4}\left\{zdz - 3bdz + 3b^2 z^{-1} dz - b^3 z^{-2} dz\right\}:$$

Hence, integrating by the rule,

$$y = \frac{A}{a^4}\left\{\frac{z^2}{2} - 3bz + 3b^2 \text{ l. } z + b^3 z^{-1}\right\} + C.$$

We now substitute for z its value, and find

$$y = \frac{A}{a^4}\left\{\begin{matrix}\frac{1}{2}(ax + b)^2 - 3b(ax + b) \\ + 3b^2 \text{ l. } (ax + b) + \dfrac{b^3}{ax + b}\end{matrix}\right\} + C.$$

110. All differentials which are rational fractions may be reduced to this form,

$$\frac{(Ax^{n-1} + Bx^{n-2} + Cx^{n-2} \ldots + T)dx}{x^n + A' x^{n-1} + B' x^{n-2} \ldots + T'}.$$

The general method of integrating such a differential consists in decomposing it into others whose denominators are more simple, which are called *partial fractions*. These are obtained as follows.

Assume the denominator of the proposed fraction equal to *zero*, thus forming the equation

$$x^n + A' x^{n-1} + B' x^{n-2} \ldots + T' = 0.$$

Let the roots of this equation be

$$x = -a,\ x = -a',\ x = -a'',\ x = -a''', \&c.$$

and supposing them all different, the first side of the equation will be (ALGEBRA, art. 99) the product of n factors,

$$x + a,\ x + a',\ x + a'',\ x + a''', \&c.$$

We now assume that the proposed fraction is the sum of the fractions

$$\frac{Ndx}{x + a}, \frac{N'dx}{x + a'}, \frac{N''dx}{x + a''}, \&c.$$

of which the denominators are the factors of the proposed fraction, and the numerators are undetermined constants. These being reduced to a common denominator, and added, the result will be a fraction identical with the proposed fraction; and by putting the co-efficients of like powers of x in their numerators equal to one another, a series of equations will be had, by which the undetermined constants N, N′, N″, &c. may be found.

As an example, suppose the differential to be integrated is

$$\frac{(Ax^2 + Bx + C)\,dx}{x^3 + A'x^2 + B'x + C'},$$

and that by the resolution of an equation we know that

$$x^3 + A'x^2 + B'x + C' = (x + a)(x + a')(x + a'').$$

setting aside dx, we assume that the fraction is equivalent to

$$\frac{N}{x + a} + \frac{N'}{x + a'} + \frac{N''}{x + a''}.$$

The sum of these is

$$\frac{N(x+a')(x+a'')+N'(x+a)(x+a'')+N''(x+a)(x+a')}{(x + a)(x + a')(x + a'')}.$$

The numerator of this fraction is, by multiplying its factors,

$$(N+N'+N'')x^2+\{N(a'+a'')+N'(a+a'')+N''(a+a')\}x$$
$$+ Na'a'' + N'aa'' + N''aa';$$

and as this must be equal to the numerator of the proposed differential, whatever be the value of x, the co-efficients of like powers of x will be equal (art. 18); hence we have these three equations,

$$N + N' + N'' = A.$$
$$N(a' + a'') + N'(a + a'') + N''(a + a') = B,$$
$$Na'a'' + N'aa'' + N''aa' = C;$$

which are only of the first degree with respect to the undetermined quantities N, N′, N′. Resolving these equations, we find N, N′, N″, and have

$$\frac{(Ax^2 + Bx + C)dx}{x^3 + A'x^2 + B'x + C'}$$
$$= \frac{Ndx}{x + a} + \frac{N'dx}{x + a'} + \frac{N''dx}{x + a''}.$$

Making $x + a = z$, we have $dx = dz$, and $\frac{Ndx}{x + a} = \frac{Ndz}{z}$, the integral of which is $N \text{ l. } z = N \text{ l. } (x + a)$; similarly,

$$\int\frac{N'dx}{x + a'} = N' \text{ l. } (x + a); \int\frac{N''dx}{x + a'} = N'' \text{ l. } (x + a'').$$

So that we have now

$$\int\frac{(Ax^2 + B x + C)dx}{x^3 + A'x^2 + B'x + C'}$$
$$= N \text{ l.} (x + a) + N \text{ l.} (x + a') + N \text{ l.} (x + a'') + \text{const.}$$
$$\text{l. } \{(x + a)^{N} \cdot (x + a')^{N'} \cdot (x + a'')^{N''}\} + \text{const.}$$

This process, which may be extended to all rational fractions whose denominators are decomposable into unequal factors of the *first* degree, has no difficulty, independent of the decomposition of the denominator into its factors, which, however, requires the numerical resolution of equations.

111. If some of the factors of the denominator of the proposed fraction are equal, the process will require to be modified to suit that case. Suppose the denominator $x^n + A'x^{n-1} +$, &c.... $+ T'$ to contain a factor $(x + a)^p$, then, for every such factor, it will be necessary to assume a partial fraction of the form

$$\frac{(Px^{p-1} + Qx^{p-2} +, \&c.... + Y)dx}{(x + a)^p}.$$

This and the other partial fractions being reduced to a common denominator, and added, and the terms of the numerator in the result being put equal to those of the numerator of the proposed differential, as before, as many independent equations will be obtained as there are co-efficients to be determined.

112. It is not difficult to see that the partial fraction suited to the case of equal factors may be transformed into an expression of the form

$$\frac{Ndx}{(x + a)^p} + \frac{N'dx}{(x + a)^{p-1}} \ldots + \frac{N''dx}{x + a};$$

therefore we may at once substitute this instead of the equivalent single fraction. We shall now have to integrate a series of differentials of the form

$$\frac{Ndx}{(x + a)^p},$$

which, by making $x + a = z$, and therefore $dx = dz$, gives

$$\int\frac{Ndx}{(x + a)^p} = \int\frac{Ndz}{z^p} = \frac{Nz^{-p+1}}{1-p}$$
$$= \frac{N}{(1-p)(x + a)^{p-1}}.$$

These will be all algebraical except the last, $\int\frac{Ndx}{x + a}$, which will involve a logarithm.

113. If there be imaginary factors, these will occur in pairs of the form $x + \alpha + \beta\sqrt{-1}$, $x + \alpha - \beta\sqrt{-1}$,

Inverse Method.

and their product will be $x^2 + 2ax + x^2 + \beta^2$. In this case the best way to proceed will be to resolve the denominator of the proposed differential into real factors of the first and of the second degree, which is always possible (see EQUATIONS). If there be several pairs of these imaginary factors, each pair the same, the denominator of the proposed differential will have factors of the form $(x^2 + 2ax + \alpha^2 + \beta^2)^q$. Then, for the single factor $x^2 + 2ax + \alpha^2 + \beta^2$, we must assume, in addition to the partial fractions, for factors of the first degree, one of this form,

$$\frac{(Kx + L)dx}{x^2 + 2ax + \alpha^2 + \beta^2};$$

and for factors of the second form, this fraction,

$$\frac{(Qx^{2q-1} + Rx^{2q-2} \ldots + Y')\,dx}{(x^2 + 2ax + \alpha^2 + \beta^2)^q};$$

or, instead of this, a series of fractions,

$$\frac{(Kx + L)\,dx}{(x^2 + 2ax + \alpha^2 + \beta^2)^q} + \frac{(K'x + L')dx}{(x^2 + 2ax + \alpha^2 + \beta^2)^{q-1}}$$
$$\ldots\ldots\ldots\ldots\ldots\ldots + \frac{(K'''x + L''')dx}{x^2 + 2ax + \alpha^2 + \beta^2};$$

the co-efficients to be determined, as before explained.

114. To integrate the fraction

$$\frac{(Kx + L)\,dx}{x^2 + 2ax + \alpha^2 + \beta^2},$$

we observe that $x^2 + 2ax + \alpha^2 + \beta^2 = (x + \alpha)^2 + \beta^2$; and if we make $x + \alpha = z$, then

$$\frac{(Kx + L)dx}{(x + \alpha)^2 + \beta^2} = \frac{(Kz + L - K\alpha)dz}{z^2 + \beta^2}$$
$$= \frac{Kzdz}{z^2 + \beta^2} + \frac{L'dz}{z^2 + \beta^2}.$$

Here L' is put for the constant quantity $L - K\alpha$. Now, the integral of the first of these differentials may be expressed by a logarithm; for, making $z^2 = u$, we have $zdz = \frac{1}{2}du$, which gives

$$\int \frac{Kzdz}{z^2 + \beta^2} = \frac{K}{2}\int\frac{du}{u} = K\tfrac{1}{2}\,\mathrm{l}.\,u = K\,\mathrm{l}.\sqrt{z^2 + \beta^2}.$$

With respect to the second part, we make $z = \beta v$, then,

$$\frac{L'dz}{z^2 + \beta^2} = \frac{L'}{\beta}\,\frac{dv}{v^2 + 1}.$$

But we have found (art. 23) that $\frac{dv}{v^2 + 1}$ is the differential of the arc whose tangent is v, which is expressed by $\tan^{-1} v$, therefore

$$\int \frac{L'}{\beta}\cdot\frac{dv}{v^2 + 1} = \frac{L'}{\beta}\tan^{-1} v + \text{const.}$$
$$= \frac{L'}{\beta}\tan^{-1}\frac{z}{\beta} + \text{const.}$$

Adding now these results, we get

$$\int \frac{(Kz + L')dz}{z^2 + \beta^2} = K\,\mathrm{l}.\sqrt{z^2 + \beta^2} + \frac{L'}{\beta}\tan^{-1}\frac{z}{\beta} + \text{const.}$$

When the value of z and L' are replaced, we have

$$\int \frac{(Kx + L)dx}{x^2 + 2ax + \alpha^2 + \beta^2} = \text{const.}$$
$$+ K\,\mathrm{l}.\sqrt{x^2 + 2ax + \alpha^2 + \beta^2} + \frac{L - K\alpha}{\beta}\tan^{-1}\frac{x + \alpha}{\beta}.$$

115. To integrate the differential

$$\frac{(Kx + L)dx}{(x^2 + 2ax + \alpha^2 + \beta^2)^q},$$

we shall at once make $x + \alpha = z$, and $L - K\alpha = L'$. By this the differential is transformed to

$$\frac{(Kz + L')dz}{(z^2 + \beta^2)^q} = \frac{Kzdz}{(z^2 + \beta^2)^q} + \frac{L'dz}{(z^2 + \beta^2)^q}.$$

To transform the first part, we make $z^2 + \beta^2 = u$, so that $zdz = \frac{du}{2}$, and consequently,

$$\int \frac{Kzdz}{(z^2 + \beta^2)^q} = \frac{K}{2}\int\frac{du}{u^q} = \frac{K}{2}\cdot\frac{u^{-q+1}}{1 - q}.$$

To integrate the second part, we assume the equation

$$\int \frac{dz}{(z^2 + \beta^2)^q} = \frac{Gz}{(z^2 + \beta^2)^{q-1}} + H\int\frac{dz}{(z^2 + \beta^2)^{q-1}};$$

that is, we assume the integral to be equal to an algebraic quantity, together with another integral whose denominator is less by an unit than the first. We now differentiate the terms of the assumed equation, observing that the removal of $\int$, the sign of an integral, is equivalent to the differentiation of that integral; we also reject such factors as are common to all the terms of the result, and thus have

$$1 = G\,(z^2 + \beta^2) - 2\,(q - 1)\,Gz^2 + H\,(z^2 + \beta^2);$$
$$\text{and } \{(3 - 2q)\,G + H\}\,z^2 + (G + H)\,\beta^2 - 1 = 0.$$

Now, that z may remain undetermined, we must have

$$(G + H)\,\beta^2 - 1 = 0, \quad (3 - 2q)\,G + H = 0.$$

From these equations, we find

$$G = \frac{1}{(2q - 2)\beta^2}, \qquad H = \frac{2q - 3}{(2q - 2)\beta^2}.$$

The values of G and H being substituted in our assumed equation, it becomes

$$\int \frac{dz}{(z^2 + \beta^2)^q} = \frac{1}{(2q - 2)\beta^2}\;\frac{z}{(z^2 + \beta^2)^{q-1}},$$
$$+ \frac{2q - 3}{(2q - 2)\beta^2}\int\frac{dz}{(z^2 + \beta^2)^{q-1}}.$$

This formula gives the means of depressing the index of the denominator of the proposed fraction; for, putting $q - 1$ instead of q, we find

$$\int \frac{dz}{(z^2 + \beta^2)^{q-1}} = \frac{1}{(2q - 4)\beta^2}\;\frac{z}{(z^2 + \beta^2)^{q-2}},$$
$$+ \frac{2q - 5}{(2q - 4)\beta^2}\int\frac{dz}{(z^2 + \beta^2)^{q-2}};$$

and again, putting $q - 2$ for q, we get

$$\int \frac{dz}{(z^2 + \beta^2)^{q-2}} = \frac{1}{(2q - 6)\beta^2}\;\frac{z}{(z^2 + \beta^2)^{q-3}},$$
$$+ \frac{2q - 7}{(2q - 6)\beta^2}\int\frac{dz}{(z^2 + \beta^2)^{q-3}}.$$

In this way the integral $\int\frac{dz}{(z^2 + \beta^2)^q}$ is expressed by an algebraic quantity, and another integral, $\int\frac{dz}{(z^2 + \beta^2)^{q-1}}$; and this last by another algebraic quantity, and the integral $\int\frac{dz}{(z^2 + \beta^2)^{q-2}}$; and so on, until we come to the integral $\int\frac{dx}{z^2 + \beta^2}$, which is known, and expressible by the arc of a circle. Here the process must stop; for the next transformation would involve the integral $\int\frac{dx}{(z^2 + \beta^2)^0}$, with

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an infinite co-efficient, from which no conclusion can be drawn. Here we see the application of a method of integration at once fertile and elegant.

From what has been explained, it appears that differentials which are rational fractions may be always integrated either algebraically or by means of logarithms or circular arcs; all that is necessary is to decompose them into partial fractions, whose denominators are either binomial or trinomial quantities.

116. We shall now give some examples of the integration of differentials which are rational fractions.

1. Let the differential be $\frac{adx}{x^2-a^2}$.

In this case the denominator $x^2-a^2=(x-a)(x+a)$; we therefore assume

$$\frac{adx}{(x-a)(x+a)}=\left\{\frac{A}{x-a}+\frac{B}{x+a}\right\}dx.$$

We now reduce the second side to a single fraction, and, leaving out dx, have

$$\frac{a}{(x-a)(x+a)}=\frac{(A+B)x+(A-B)a}{(x-a)(x+a)};$$

therefore $a=(A+B)x+(A-B)a$.

Now, x being indeterminate, according to the principle of art. 18, we must have

$$(A-B)a=a, \quad A+B=0;$$

these equations give $A=\frac{1}{2}$, $B=-\frac{1}{2}$; the proposed differential is now

$$\frac{adx}{x^2-a^2}=\frac{1}{2}\frac{dx}{x-a}-\frac{1}{2}\frac{dx}{x+a};$$

and, by integrating,

$$\int\frac{adx}{x^2-a^2}=\tfrac{1}{2}\,\text{l.}\,(x-a)-\tfrac{1}{2}\,\text{l.}\,(x+a)+C,$$

$$=\tfrac{1}{2}\,\text{l.}\,\frac{x-a}{x+a}+C=\text{l.}\sqrt{\frac{x-a}{x+a}}+C.$$

2. Let the differential be $\frac{a^3+b^2x^2}{a^2x-x^3}dx$.

The factors of the denominator are x and a^2-x^2, which last resolves into $(a-x)(a+x)$; therefore, leaving out dx, we assume

$$\frac{a^3+bx^2}{x(a-x)(a+x)}=\frac{A}{x}+\frac{B}{a-x}+\frac{C}{a+x}.$$

The second side of this equation, by reducing its terms to a common denominator, and adding, is

$$\frac{Aa^2+a(B+C)x+(B-A-C)x^2}{x(a-x)(a+x)}.$$

By equating the co-efficients of the powers of x, we have

$$Aa^2=a^3, \quad a(B+C)=0, \quad B-A-C=b.$$

Here there are three unknown quantities, viz. A, B, C, and three simple equations, therefore they may be found, as taught in ALGEBRA, sect. viii.; and accordingly we have

$$A=a, \quad B=\tfrac{1}{2}(a+b), \quad C=-\tfrac{1}{2}(a+b),$$

$$\frac{a^3+bx^2}{a^2x-x^3}dx=\frac{adx}{x}+\frac{a+b}{2(a-x)}dx-\frac{a+b}{2(a+x)}dx;$$

and, integrating,

$$\int\frac{a^3+bx^2}{a^2x-x^3}dx=a\,\text{l.}\,x-\frac{a+b}{2}\,\text{l.}\,(a-x)$$

$$-\frac{a+b}{2}\,\text{l.}\,(a+x)+C.$$

By the nature of logarithms l. P + l. Q = l. (PQ) and n l. P = l. P^n; hence the integral may be otherwise expressed thus,

$$\int\frac{a^3+bx^2}{a^2x-x^3}dx=\text{l.}\,\frac{x^a}{(a^2-x^2)^{\frac{1}{2}(a+b)}}+C.$$

3. Let the differential be $\frac{3x-5}{x^2-6x+8}dx$.

To resolve the denominator into simple factors, we make $x^2-6x+8=0$, and find the roots of this equation to be $x=2$, and $x=4$; therefore, $x^2-6x+8=(x-2)(x-4)$. To decompose the fraction, leaving out dx, we now assume

$$\frac{3x-5}{(x-2)(x-4)}=\frac{A}{x-2}+\frac{B}{x-4},$$

$$=\frac{(A+B)x-4A-2B}{(x-2)(x-4)}.$$

Hence, equating the like terms in the numerators, we have

$$A+B=3, \quad -4A-2B=-5.$$

From these equations we find $A=-\frac{1}{2}$, $B=\frac{7}{2}$, and

$$\int\frac{(3x-5)\,dx}{x^2-6x+8}=-\tfrac{1}{2}\int\frac{dx}{x-2}+\frac{7}{2}\int\frac{dx}{x-4},$$

$$=\frac{7}{2}\,\text{l.}\,(x-4)-\tfrac{1}{2}\,\text{l.}\,(x-2)+C.$$

4. As an example of equal simple factors in the denominator, let the differential be

$$\frac{x^2dx}{(x^2-a^2)(x-a)}=\frac{x^2dx}{(x-a)^2(x+a)}.$$

In this case we assume (art. 112),

$$\frac{x^2}{(x-a)^2(x+a)}=\frac{A}{(x-a)^2}+\frac{B}{x-a}+\frac{C}{x+a}$$

$$=\frac{A(x+a)+B(x^2-a^2)+C(x-a)^2}{(x-a)^2(x+a)}$$

$$=\frac{Aa-Ba^2+Ca^2+(A-2aC)x+(B+C)x^2}{(x-a)^2(x+a)}.$$

By equating like terms of the numerators, we have

$$Aa-Ba^2+Ca^2=0, \quad A-2aC=0, \quad B+C=1.$$

Hence, by the ordinary process for resolving simple equations involving three unknown quantities, we find

$$A=\tfrac{1}{2}a, \quad B=\tfrac{3}{4}, \quad C=\tfrac{1}{4},$$

and the transformed differential is

$$\frac{x^2dx}{(x-a)^2(x+a)}=\frac{a}{2}\frac{dx}{(x-a)^2}+\frac{3}{4}\frac{dx}{x-a}+\frac{1}{4}\frac{dx}{x+a}.$$

By integration we have

$$\int\frac{dx}{(x-a)^2}=\frac{-1}{x-a},\int\frac{dx}{x-a}=\text{l.}(x-a),\int\frac{dx}{x+a}=\text{l.}\,(x+a);$$

therefore, supplying the co-efficients of the partial fractions, and, as usual, an indeterminate constant, we have

$$\int\frac{x^2dx}{(x^2-a^2)(x-a)}=-\frac{a}{2}\frac{1}{x-a}+\tfrac{3}{4}\,\text{l.}\,(x-a)$$

$$+\tfrac{1}{4}\,\text{l.}\,(x+a)+const.$$

5. Let the differential be $\frac{x^3+x^2+2}{x(x+1)^2(x-1)^2}dx$.

The denominator contains two pairs of equal factors; we therefore assume (art. 112) $\frac{x^3+x^2+2}{x(x+1)^2(x-1)^2}$ equal to

$$\frac{A}{x}+\frac{B}{(x+1)^2}+\frac{C}{(x+1)}+\frac{D}{(x-1)^2}+\frac{E}{x-1}.$$

By proceeding as in the foregoing examples, uniting the partial fractions into one fraction, and equating the co-efficients of like powers of x, we find

$$A=2, \; B=-\tfrac{1}{2}, \; C=-\tfrac{5}{4}, \; D=1, \; E=-\tfrac{3}{4}.$$

The proposed differential is now decomposed into these,

$$\frac{2dx}{x}-\tfrac{1}{2}\frac{dx}{(x+1)^2}-\tfrac{5}{4}\frac{dx}{x+1}+\frac{dx}{(x-1)^2}-\tfrac{3}{4}\frac{dx}{x-1}.$$

Hence, by integration,

$$\int\frac{x^3+x^2+2}{x(x+1)^2(x-1)^2}dx=2\,\text{l}.\,x+\tfrac{1}{2}\frac{1}{x+1}-\tfrac{5}{4}\,\text{l}.(x+1)$$
$$-\frac{1}{x-1}-\tfrac{3}{4}\,\text{l}.\,(x-1)+\text{const.}$$

6. As an example of a fraction, in which one of the factors in the denominator is a function of the second degree, which does not admit of resolution into real factors of the first degree, let the differential to be integrated be $\frac{a+bx}{x^3-1}dx.$

The denominator $x^3-1=(x-1)\,(x^2+x+1)$. The expression x^2+x+1 is of that kind which cannot be resolved into real factors, although it may into two imaginary factors. For, making $x^2+x+1=0$, and resolving this quadratic equation, we find $x=\frac{-1\pm\sqrt{-3}}{2}$, and $x^2+x+1=(x+\frac{1}{2}+\frac{1}{2}\sqrt{-3})(x+\frac{1}{2}-\frac{1}{2}\sqrt{-3})$.

To avoid impossible quantities, we assume (art. 113),

$$\frac{a+bx}{(x-1)\,(x^2+x-1)}=\frac{A}{x-1}+\frac{Bx+C}{x^2+x-1}.$$

Reducing now the partial fractions to a common denominator, and comparing the co-efficients of like powers, we find

$$A=\tfrac{1}{3}(a\dotplus b),\ B=-\tfrac{1}{3}(a+b),\ C-\tfrac{1}{3}(2a-b).$$

The proposed differential and its equivalent transformed expression will therefore be

$$\frac{a+bx}{(x-1)\,(x^2+x+1)}dx=\frac{a+b}{3}\cdot\frac{dx}{x-1}$$
$$-\tfrac{1}{3}\frac{(a+b)\,x+2a-b}{x^2+x+1}dx.$$

The first integral of these differentials is expressible by a logarithm; to transform the second, we put x^3+x+1 under the form $(x+\frac{1}{2})^2+\frac{3}{4}$, and make $x+\frac{1}{2}=z$; then, $x=z-\frac{1}{2}$, $dx=dz$, $(a+b)\,x+2a-b=(a+b)\,z+\frac{3}{2}(a-b)$, and

$$\tfrac{1}{3}\frac{(a+b)\,x+2a-b}{x^2+x+1}dx=\frac{a+b}{3}\frac{zdz}{z^2+\frac{3}{4}}$$
$$+\frac{a-b}{2}\frac{dz}{z^2+\frac{3}{4}}.$$

The first of these two is also expressible by a logarithm. To simplify the second, we make $z^2=\frac{3}{4}v^2$; so that $dz=\frac{\sqrt{3}}{2}dv$, and $\frac{dz}{z^2+\frac{3}{4}}=\frac{2}{\sqrt{3}}\frac{dv}{1+v^2}$. On the whole, the differential prepared for integration by known rules is

$$\frac{(a+bx)\,dx}{x^3-1}=\frac{a+b}{3}\frac{dx}{x-1}-\frac{a+b}{3}\frac{zdz}{z^2+\frac{3}{4}}$$
$$-\frac{a-b}{\sqrt{3}}\frac{dv}{1+v^3};$$

and, integrating,

$$\int\frac{(a+bx)\,dx}{x^3-1}=\frac{a+b}{3}\,\text{l}.\,(x-1)-\frac{a+b}{6}\,\text{l}.\,(z^2+\tfrac{3}{4})$$
$$-\frac{a-b}{\sqrt{3}}\tan^{-1}v+\text{const.};$$

this integral, by putting for z and v their values in terms of x, will also be

$$\int\frac{(a+bx)\,dx}{x^3-1}=\frac{a+b}{3}\,\text{l}.\,\frac{x-1}{\sqrt{x^2+x+1}}$$
$$-\frac{a-b}{\sqrt{3}}\tan^{-1}\left\{\frac{2x+1}{\sqrt{3}}\right\}+\text{const.}$$

117. The method of resolving a rational fraction into its component partial fractions, by the theory of indeterminate co-efficients (art. 110–113), is the most elementary of any; it is however tedious. We shall therefore now show how the labour may be abridged.

Let $\frac{U}{V}$ be a rational fraction in its lowest terms, the denominator of which has unequal divisors of the first degree; let $x+a$ be one of them, and Q the product of all the other factors, whether of the first or second degree; so that

$$V=(x+a)\,Q.$$

In this case we assume

$$\frac{U}{V}=\frac{A}{x+a}+\frac{P}{Q},$$

where A is independent of x, and P and Q are functions of x, the latter being supposed known. By reducing to a common denominator, and remembering that $V=(x+a)\,Q$, we have the identical equation

$$U=AQ+P\,(x+a),$$

in which, by hypothesis, neither U nor Q are divisible by $x+a$. Let us make $x+a=0$, that is, $x=-a$, and upon that hypothesis let u and q denote the values of U and Q respectively; then the equation becomes $u=Aq$, and hence $A=\frac{u}{q}$. This determines the numerator of the partial fraction $\frac{A}{x+a}$, and in the same way may the numerators of all the partial fractions be found.

As an example, let the fraction to be resolved be

$$\frac{U}{V}=\frac{mx+n}{(x+a)\,(x-b)}=\frac{A}{x+a}+\frac{B}{x-b};$$
$$\text{then, }\frac{mx+n}{x-b}=A+\frac{B}{x-b}(x+a),$$
$$\text{and }\frac{mx+n}{x+a}=B+\frac{A}{x+a}(x-b).$$

Making $x=-a$, the first of these gives

$$A=\frac{-ma+n}{-a-b}=\frac{ma-n}{a+b};$$

and making $x=+b$, the second gives $B=\frac{mb+n}{a+b}$.

Hence we have

$$\frac{mx+n}{(x+a)\,(x-b)}=\frac{1}{a+b}\left\{\frac{ma-n}{x+a}+\frac{mb+n}{x-b}\right\}.$$

118. The differential calculus may be applied to the determination of the constants A, B, &c. Resuming the equation $V=(x+a)\,Q$, we have, by differentiation, $\frac{dV}{dx}=Q+\frac{dQ}{dx}(x+a)$. Suppose that when $x=-a$, then $\frac{dV}{dx}$ becomes v', and, as before, that Q becomes q, the differential equation will now become $v'=q$; and since $A=\frac{u}{q}$, therefore also $A=\frac{u}{v'}$.

In the preceding example, in which $V=(x+a)\,(x-b)$, we have

$$\frac{dV}{dx}=2x+a-b.$$

The supposition that $x=-a$ makes $\frac{dV}{dx}=-a-b=v'$, and the supposition that $x=+b$ makes $\frac{dV}{dx}=a+b=v'$; these values of $v'=q$ give the values of A and B, the same as before.

119. Let us now suppose, that in the fraction $\frac{\text{U}}{\text{V}}$, the denominator $\text{V} = (x+a)^n\,\text{Q}$, that is, the product of n equal factors, and Q, the product of all the remaining factors; so that the assumption is $\frac{\text{U}}{\text{V}} = \frac{\text{U}}{\text{Q}\,(x+a)^n} =$

$$\frac{\text{A}}{(x+a)^n} + \frac{\text{B}}{(x+a)^{n-1}} + \frac{\text{C}}{(x+a)^{n-2}} \ldots + \frac{\text{E}}{x+a} + \frac{\text{P}}{\text{Q}},$$

where A, B, C, ...E are constant quantities, and P, Q functions of x. In this case, multiplying all the terms by $(x+a)^n$, we have

$$\frac{\text{U}}{\text{Q}} = \text{A} + \text{B}\,(x+a) + \text{C}\,(x+a)^2 \ldots$$
$$+ \text{E}\,(x+a)^{n-1} + \frac{\text{P}}{\text{Q}}\,(x+a)^n.$$

The supposition that $x = -a$ gives to U and Q particular values, which, as before, we denote by u and q; the terms which contain $x+a$ all vanish, and we have $\text{A} = \frac{u}{q}$; thus A is known.

Since $\frac{\text{U}-\text{AQ}}{\text{Q}} = \text{B}\,(x+a) + \text{C}\,(x+a)^2 + \&\text{c.}$ the numerator, U — AQ, of the first side of the equation must necessarily be divisible by $x+a$, and may be expressed by $\text{U}_1\,(x+a)$. We have now

$$\frac{\text{U}_1}{\text{Q}} = \text{B} + \text{C}\,(x+a) \ldots + \text{E}\,(x+a)^{n-2} + \frac{\text{P}}{\text{Q}}\,(x+a)^{n-1}.$$

The quantity U_1 not being divisible by $x+a$, the assumption that $x = -a$ will give it a particular value, which we shall denote by u_1. This assumption will give Q the same particular value as before; the terms which contain $(x+a)$ as a factor will all vanish, and we shall have $\text{B} = \frac{u_1}{q}$. In this way may all the remaining numerators C, &c. to E be found.

As a particular example of this process, let the fraction $\frac{\text{U}}{\text{V}}$ be $\frac{x^2}{(1-x)^3\,(1+x^2)}$. We assume

$$\frac{x^2}{(1+x^2)\,(1-x)^3} = \frac{\text{A}}{(1-x)^3} + \frac{\text{B}}{(1-x)^2} + \frac{\text{C}}{1-x} + \frac{\text{P}}{1+x^2};$$

hence, multiplying by $(1-x)^3$, we have

$$\frac{x^2}{1+x^2} = \text{A} + \text{B}\,(1-x) + \text{C}\,(1-x)^2 + \frac{\text{P}}{1+x^2}(1-x)^3.$$

Making $1-x=0$, or $x=1$, we have $\text{A} = \frac{1}{2}$, and $\frac{x^2}{1+x^2} - \text{A} = -\frac{1+x}{2(1+x^2)}(1-x) = \text{B}(1-x) + \text{C}(1-x)^2 + \frac{\text{P}}{1+x^2}(1-x)^3$,

and $-\frac{1+x}{2(1+x^2)} = \text{B} + \text{C}\,(1-x) + \frac{\text{P}}{1+x^2}\,(1-x)^2$;

again, making $x=1$, we find $\text{B} = -\frac{1}{2}$, and

$-\frac{1+x}{2(1+x^2)} - \text{B} = \frac{-x}{2(1+x^2)}\,(1-x) = \text{C}\,(1-x) + \frac{\text{P}}{1+x^2}(1-x)^2$;

$$\text{and } \frac{-x}{2\,(1+x^2)} = \text{C} + \frac{\text{P}}{1+x^2}(1-x).$$

Lastly, making $x = 1$, we have $\text{C} = -\frac{1}{4}$, and the fraction

$$\frac{x^2}{(1+x^2)(1-x)^3} = \tfrac{1}{2}\frac{1}{(1-x)^3} - \tfrac{1}{2}\frac{1}{(1-x)^2} - \tfrac{1}{4}\frac{1}{1-x} + \frac{\text{P}}{1+x^2}.$$

120. In this case we may also find the numerators A, B, C, &c. by the differential calculus. From the equation of art. 119 we have

$$\text{U} = \text{Q}\begin{cases}\text{A} + \text{B}\,(x+a) + \text{C}\,(x+a)^2 \ldots \\ \quad + \text{E}(x+a)^{n-1} + \text{P}(x+a)^n.\end{cases}$$

If we now differentiate this equation $(n-1)$ times in succession, and then make $x+a=0$, both in this equation and those which we deduce from it, there will arise

$$\text{U} = \text{AQ},$$
$$\frac{d\text{U}}{dx} = \text{A}\,\frac{d\text{Q}}{dx} + \text{BQ},$$
$$\frac{d^2\text{U}}{dx^2} = \text{A}\,\frac{d^2\text{Q}}{dx^2} + 2\text{B}\,\frac{d\text{Q}}{dx} + 2\text{CQ},$$
$$\frac{d^3\text{U}}{dx^3} = \text{A}\,\frac{d^3\text{Q}}{dx^3} + 3\text{B}\,\frac{d^2\text{Q}}{dx^2} + 6\text{C}\,\frac{d\text{Q}}{dx} + 6\text{DQ},$$
&c.

equations which determine each of the unknown quantities A, B, C, &c. by means of those which precede it, it being well understood that we substitute after each differentiation $-a$ in the place of x in the differential co-efficients. In this case the most simple way of determining Q will be to divide V by $(x-a)^n$. But it may also be found by differentiation, as in art. 118.

121. Let us now suppose that $\frac{\text{U}}{\text{V}}$, the fraction to be decomposed, has a factor of the second degree, viz. $x^2 + 2\alpha x + \alpha^2 + \beta^2$, which cannot be resolved into two real factors of the first degree.

In this case, $\text{V} = (x^2 + 2\alpha x + \alpha^2 + \beta^2)\,\text{Q}$, and we assume

$$\frac{\text{U}}{\text{V}} = \frac{\text{A}x + \text{B}}{x^2 + 2\alpha x + \alpha^2 + \beta^2} + \frac{\text{P}}{\text{Q}}.$$

Then, $\text{U} = (\text{A}x + \text{B})\,\text{Q} + \text{P}\,(x^2 + 2\alpha x + \alpha^2 + \beta^2)$.

If we substitute for x one of the imaginary roots of the equation $x^2 + 2\alpha x + \alpha^2 + \beta^2 = 0$, the term containing P will disappear, and the result will contain two kinds of terms; one real, and the other imaginary. We must now put the real quantities equal to each other, and also the imaginary quantities; thus two equations will be obtained by which A and B may be determined.

Let the fraction be

$$\frac{x}{(x-1)\,(x^2+x+1)} = \frac{\text{A}x + \text{B}}{x^2+x+1} + \frac{\text{P}}{\text{Q}}.$$

Then $x = (\text{A}x + \text{B})\,(x-1) + \text{P}\,(x^2+x+1)$.

Now $x^2+x+1=0$ gives $x = -\frac{1}{2} \pm \frac{1}{2}\sqrt{-3}$; therefore, by substituting in the last equation, it becomes, after collecting the terms,

$$-\tfrac{1}{2} \pm \tfrac{1}{2}\sqrt{-3} = -\tfrac{3}{2}\text{B} \pm (\tfrac{1}{2}\text{B} - \text{A})\sqrt{-3}.$$

Hence $-\frac{3}{2}\text{B} = -\frac{1}{2}$ and $\frac{1}{2}\text{B} - \text{A} = \frac{1}{2}$, therefore $\text{B} = \frac{1}{3}$ and $\text{A} = -\frac{1}{3}$.

122. In the last place, let us consider the case in which the fraction $\frac{\text{U}}{\text{V}} =$

$$\frac{\text{A}x + \text{B}}{(x^2 + 2\alpha x + \alpha^2 + \beta^2)^n} + \frac{\text{C}x + \text{D}}{(x^2 + 2\alpha x + \alpha^2 + \beta^2)^{n-1}} \ldots\ldots + \frac{\text{P}}{\text{Q}};$$

and here $\text{V} = (x^2 + 2\alpha x + \alpha^2 + \beta^2)^n\,\text{Q}$. We have now

$$\frac{\text{U}}{\text{Q}} = (\text{A}x + \text{B}) + (\text{C}x + \text{D})\,(x^2 + 2\alpha x + \alpha^2\beta^2) \ldots$$
$$+ \frac{\text{P}}{\text{Q}}(x^2 + 2\alpha x + \alpha^2 + \beta^2)^n\text{V}.$$

This case is compounded of the two preceding, and must be treated in the same manner. In the first place, we substitute for x, one of the roots of the equation, $x^2 + 2\alpha x + \alpha^2 + \beta^2 = 0$, by which all the terms containing this quantity disappear, and the equation is reduced to $\frac{V}{Q} = Ax + B$; and here V and Q are functions of the particular value of x, which satisfies the above-mentioned equation. As in the last case, we shall have an equation of the form $r + s\sqrt{-1} = r' + s'\sqrt{-1}$, r and s being composed of constants and the indeterminate quantities A, B; and these last will be found from the equations

$$r = r', \quad s = s'.$$

We now differentiate the preceding equation, and, after omitting the terms in the result that contain $x^2 + 2\alpha x + \alpha^2 + \beta^2$, have

$$\frac{d\left(\frac{V}{Q}\right)}{dx} = A + (2x + 2\alpha)(Cx + D).$$

By substituting in this expression the imaginary value of x, which satisfies the equation $x^2 + 2\alpha x + \alpha^2 + \beta^2 = 0$, and putting the real and imaginary terms on each side equal, two equations will be obtained which determine C and D.

As an example, let the fraction be $\frac{x^3 - 2x^2 + x - 3}{(x^2 - 2x + 2)^2}$. We assume it

$$= \frac{Ax + B}{(x^2 - 2x + 2)^2} + \frac{Cx + D}{x^2 - 2x + 2}.$$

By reducing to a common denominator, we find

$$x^3 - 2x^2 + x - 3 = Ax + B + (Cx + D)(x^2 - 2x + 2),$$

one of the roots of the equation $x^2 - 2x + 2 = 0$ is $x = 1 + \sqrt{-1}$; this being substituted for x, the equation, becomes

$$-4 - \sqrt{-1} = A + B + A\sqrt{-1}.$$

Hence, to determine A and B, we have $A + B = -4$, and $A = -1$; therefore $B = -3$. Substituting the values of A and B, and transposing, we have

$$x^3 - 2x^2 + 2x = (Cx + D)(x^2 - 2x + 2);$$

and, taking the differentials, and dividing by dx,

$$3x^2 - 4x + 2 = (Cx + D)(2x - 2) +, \text{\&c.}$$

By again substituting $1 + \sqrt{-1}$ for x, this equation becomes

$$-2 + 2\sqrt{-1} = -2C + 2(C + D)\sqrt{-1};$$

hence $C = 1$, $D = 0$, and the proposed fraction is equivalent to

$$-\frac{x + 3}{(x^2 - 2x + 2)^2} + \frac{x}{x^2 - 2x + 2}.$$

There is an extensive class of differentials, rational fractions, in which the denominator has the form $x^{2m} \pm 2x^n \cos\alpha + 1$; also of this form, $x^n \pm 1$. How these functions may be resolved into factors of the first and second degrees has been explained in ALGEBRA, art. 274–278. This resolution being effected, the integration may be performed as has been explained.

Integrals of Irrational Fractions.

123. When a differential involves irrational functions, if by any means these can be transformed into others entirely rational, their integration may be effected by the rules already explained.

For example, let the differential be

$$\frac{(1 + \sqrt{x} - \sqrt[3]{x^2})\,dx}{1 + \sqrt[3]{x}}.$$

It is evident, that making $x = z^6$, all the extractions indicated by the radical signs may be effected; and since $dx = 6z^5dz$, the differential is transformed to

$$\frac{6z^5dz(1 + z^3 - z^4)}{1 + z^2};$$

and by actually dividing the numerator by the denominator, this last may be expressed thus,

$$-6(z^7 - z^6 - z^5 + z^4 - z^2 + 1)\,dz - \frac{6dz}{1 + z^2},$$

whose integral is

$$-6\left(\frac{z^8}{8} - \frac{z^7}{7} - \frac{z^6}{6} + \frac{z^5}{5} - \frac{z^3}{3} + z - \tan^{-1} z\right) + \text{const.}$$

By replacing the value of z, viz. $x^{\frac{1}{6}}$, the integral may be expressed in terms of x.

124. We shall now consider those irrational functions which include the radical $\sqrt{a + bx + cx^2}$ only, and which appear under one or other of the two forms,

$$P\,dx\sqrt{a + bx + cx^2}, \quad \frac{P\,dx}{\sqrt{a + bx + cx^2}},$$

where P denotes any rational function of x. These may, however, be included in one; for if the first be multiplied by the radical, and the same quantity written under it as a denominator, it becomes

$$\frac{P(a + bx + cx^2)\,dx}{\sqrt{a + bx + c^2}},$$

an expression of the same kind as the second.

We begin with the simple form, $\frac{dx}{\sqrt{a + bx + cx^2}}$, which, however, has two cases, according as the sign of c in the denominator is positive or negative.

125. I. To integrate the differential $\frac{dx}{\sqrt{a + bx + cx^2}}$.

$$\text{Assume } \sqrt{a + bx + cx^2} = py + \frac{q}{y} \quad\ldots\ldots\ldots\ldots(1)$$

Here p and q are indeterminate constant quantities, to which such values are to be given as shall serve to transform the proposed differential into another that may be a rational fraction; we have now

$$a + bx + cx^2 = p^2y^2 + 2pq + \frac{q^2}{y^2}.$$

To make the left-hand side of this equation a perfect square, we transpose its first term, then multiply both sides by c, and add $\frac{b^2}{4}$ to each side of the result; it then becomes

$$\frac{b^2}{4} + bcx + c^2x^2 = c\left(p^2y^2 + 2pq - a + \frac{b^2}{4c} + \frac{q^2}{y^2}\right).$$

The second side will also become a square if we make

$$2pq - a + \frac{b^2}{4c} = -2pq,$$

$$\text{or } 4pq = \frac{4ac - b^2}{4c},$$

which is evidently always a possible assumption; by this, the equation becomes

$$\frac{b^2}{4} + bcx + c^2x^2 = c\left(p^2y^2 - 2pq + \frac{q^2}{y^2}\right);$$

and hence, by taking the square roots,

$$\frac{b}{2} + cx = \sqrt{c}\left(py - \frac{q}{y}\right) \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

From this, by differentiation, we obtain

$$\sqrt{c}\,dx = \frac{dy}{y}\left(py + \frac{q}{y}\right) = \frac{dy}{y}\sqrt{a + bx + cx^2};$$

and hence,

$$\frac{dx}{\sqrt{a + bx + cx^2}} = \frac{1}{\sqrt{c}}\,\frac{dy}{y} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Dividing now both sides of equation (2) by $\sqrt{c}$, and adding the results to equation (1), we get

$$\frac{b}{2\sqrt{c}} + x\sqrt{c} + \sqrt{a+bx+cx^2} = 2py;$$

and, taking the logarithms,

$$\text{l.}\left(\frac{b}{2\sqrt{c}} + x\sqrt{c} + \sqrt{a+bx+cx^2}\right) = \text{l.}\,y + \text{l.}\,(2p) \ldots (4)$$

Now $\text{l.}\,y = \int\frac{dy}{y} + \text{C}$; here, C being any constant whatever, we may suppose it $= \text{C}' - \text{l.}\,(2p)$, where C′ denotes another indeterminate constant; therefore,

$$\text{l.}\,y + \text{l.}\,(2p) = \int\frac{dy}{y} + \text{C}'.$$

By comparing this last equation with (3) and (4), we find

$$\int\frac{dx}{\sqrt{a+bx+cx^2}},$$

$$= \frac{1}{\sqrt{c}}\,\text{l.}\left(\frac{b}{2\sqrt{c}} + x\sqrt{c} + \sqrt{a+bx+cx^2}\right) + \text{C},$$

$$= \frac{1}{\sqrt{c}}\,\text{l.}\left(b + 2cx + 2\sqrt{c}\sqrt{a+bx+cx^2}\right) + \text{C}.$$

These logarithmic functions differ from each other only by the constant l $(2\sqrt{c}.)$

126. II. To integrate the differential $\frac{dx}{\sqrt{a+bx-cx^2}}$, assume $\sqrt{a+bx-cx^2} = p\sin\varphi$ ....(1)
p representing here an indeterminate constant, and φ a variable angle. Then

$$a+bx-cx^2 = p^2\sin^2\varphi = p^2 - p^2\cos^2\varphi;$$

and hence, proceeding as in last article,

$$\frac{b^2}{4} - bcx + c^2x^2 = cp^2\cos^2\varphi + \frac{b^2}{4} + ac - p^2c.$$

The left-hand side of the equation is now a complete square, and to make the right also a square, we assume that

$$cp^2 = \frac{b^2}{4} + ac, \text{ or } p\sqrt{c} = \frac{\sqrt{b^2+4ac}}{2} \ldots\ldots\ldots (2)$$

and thus obtain

$$\frac{b^2}{4} - bcx + c^2x^2 = cp^2\cos^2\varphi,$$

and, taking the square roots,

$$\frac{b}{2} - cx = \sqrt{c}\,p\cos\varphi \ldots\ldots\ldots\ldots\ldots (3)$$

and hence, differentiating, and dividing by $\sqrt{c}$,

$$dx = \frac{d\varphi}{\sqrt{c}}p\sin\varphi = \frac{d\varphi}{\sqrt{c}}\sqrt{a+bx-cx^2};$$

and hence,

$$\frac{dx}{\sqrt{a+bx-cx^2}} = \frac{1}{\sqrt{c}}\,d\varphi.$$

Taking now the integral, we have

$$\int\frac{dx}{\sqrt{a+bx-cx^2}} = \frac{1}{\sqrt{c}}\varphi + \text{const.}$$

To determine φ, we have, (3) and (2),

$$\cos\varphi = \frac{b-2cx}{2\sqrt{c}\,p} = \frac{b-2cx}{\sqrt{b^2+4ac}}.$$

Therefore,

$$\int\frac{dx}{\sqrt{a+bx-cx^2}} = \frac{1}{\sqrt{c}}\cos^{-1}\frac{b-2cx}{\sqrt{b^2+4ac}} + \text{C}.$$

We have also

$$\int\frac{dx}{\sqrt{a+bx-cx^2}} = \frac{1}{\sqrt{c}}\sin^{-1}\frac{2cx-b}{\sqrt{b^2+4ac}} + \text{C};$$

for the angle whose cosine is any number v differs from the angle whose sine is $-v$ by a right angle, which is a constant, and therefore the differentials of these angles will be the same expression.

127. We shall now integrate the formula

$$\frac{x^n dx}{\sqrt{a+bx+cx^2}},$$

n being any whole number. We put

$$\text{X} = \sqrt{a+bx+cx^2},\quad y = x^m\sqrt{a+bx+cx^2} = x^m\text{X},$$

$$\text{then } y^2 = ax^{2m} + bx^{2m+1} + cx^{2m+2},$$

and differentiating, we have $2ydy =$

$$(2max^{2m-1} + (2m+1)bx^{2m} + (2m+2)cx^{2m+1})dx;$$

and hence, dividing by $y = x^m\text{X}$,

$$2dy = 2ma\frac{x^{m-1}dx}{\text{X}} + (2m+1)b\frac{x^m dx}{\text{X}}$$

$$+ (2m+2)c\frac{x^{m+1}dx}{\text{X}}.$$

Let us now make $m+1 = n$, and therefore $m = n-1$, $m-1 = n-2$, $2m = 2n-2$, $2m+1 = 2n-1$, $2m+2 = 2n$; thus we obtain

$$2dy = (2n-2)a\frac{x^{n-2}dx}{\text{X}} + (2n-1)b\frac{x^{n-1}dx}{\text{X}}$$

$$+ 2nc\frac{x^n dx}{\text{X}};$$

and hence, by proper arrangement of the terms,

$$\frac{x^n ax}{\text{X}} = \frac{dy}{nc} - \frac{2n-1}{2n}\cdot\frac{b}{c}\cdot\frac{x^{n-1}dx}{\text{X}} - \frac{n-1}{n}\cdot\frac{a}{c}\cdot\frac{x^{n-2}dx}{\text{X}};$$

and, by integration, and putting for y and X the functions they represent, we have

$$\int\frac{x^n dx}{\sqrt{a+bx+cx^2}} = \frac{1}{nc}x^{n-1}\sqrt{a+bx+cx^2}$$

$$- \frac{2n-1}{2n}\cdot\frac{b}{c}\int\frac{x^{n-1}dx}{\sqrt{a+bx+cx^2}}$$

$$- \frac{n-1}{n}\cdot\frac{a}{c}\int\frac{x^{n-2}dx}{\sqrt{a+bx+cx^2}}.$$

The proposed integral is now expressed by an algebraic function, and two other integrals of the same form, but in which the exponents of x are of lower degrees. We have found its value (art. 125, 126) when $n = 0$, a case to which the formula just found does not apply, because then, n entering into the denominators of the fractions, they become infinite. When $n = 1$, the last of the two integrals in the second side of the equation vanishes, because its coefficient $= 0$, and we have

$$\int\frac{xdx}{\sqrt{a+bx+cx^2}} = \frac{1}{c}\sqrt{a+bx+cx^2}$$

$$- \frac{b}{2c}\int\frac{dx}{\sqrt{a+bx+cx^2}}.$$

Knowing now the integrals in the cases of $n = 0$ and $n = 1$, the preceding general formula gives it in the case of $n = 2$; and in the case of $n = 3$, it is found from the cases of $n = 1$ and $n = 2$; and so on to any extent, supposing n to be a positive number.

128. When n is negative, the formula will be better under another form. Writing $-n$ instead of $+n$, and arranging the terms of the result anew, we have

$$\int\frac{dx}{x\sqrt{}^{n}\overline{a+bx+cx^2}}=\frac{-1}{(n-1)a}\,\frac{\sqrt{a+bx+cx^2}}{x^{n-1}}$$
$$-\frac{2n-3}{2n-2}\cdot\frac{b}{a}\int\frac{dx}{x^{n-1}\sqrt{a+bx+cx^2}}$$
$$-\frac{n-2}{n-1}\cdot\frac{c}{a}\int\frac{dx}{x^{n-2}\sqrt{a+bx+cx^2}}.$$

In this formula, n is understood to be positive.

129. This formula of transformation will not apply to the case of $n=1$, because then the fractions which have $n-1$ in the denominator become infinite. It is therefore necessary to investigate the integral of $\frac{dx}{x\sqrt{a+bx+cx^2}}$ separately. Let $x=\frac{1}{y}$; then $\frac{dx}{x}=\frac{-dy}{y}$, and

$$\frac{dx}{x\sqrt{a+bx+cx^2}}=\frac{-dy}{\sqrt{c+by+ay^2}}.$$

This transformed differential has two cases, according as a is positive or negative; when a is positive, the integral is, by article 125,

$$-\frac{1}{\sqrt{a}}\,\mathrm{l.}\,(b+2ay+2\sqrt{a}\,\sqrt{c+by+ay^2})+\mathrm{C}.$$

We are at liberty to give the radical $\sqrt{a}$ either the sign $+$ or the sign $-$; therefore, giving it the latter, the integral is

$$\frac{1}{\sqrt{a}}\,\mathrm{l.}\,(b+2ay-2\sqrt{a}\,\sqrt{c+by+ay^2})+\mathrm{C};$$

and hence, substituting for y its equivalent $\frac{1}{x}$, we have

$$\int\frac{dx}{x\sqrt{a+bx+cx^2}}$$
$$=\frac{1}{\sqrt{a}}\,\mathrm{l.}\,\frac{2a+bx-2\sqrt{a}\,\sqrt{a+bx+cx^2}}{x}+\mathrm{C};$$

observing, as above stated, that the radical $\sqrt{a}$ may have the sign $+$ and also the sign $-$.

In the second case we have

$$\frac{dx}{x\sqrt{-a+bx+cx^2}}=\frac{-dy}{\sqrt{c+by-ay^2}}.$$

Now, by art. 126,

$$\int\frac{-dy}{\sqrt{c+by-a^2y^2}}=-\frac{1}{\sqrt{a}}\sin^{-1}\frac{2ay-b}{\sqrt{b^2+4ac}}+\mathrm{C}$$
$$=\frac{1}{\sqrt{a}}\cos^{-1}\frac{2ay-b}{\sqrt{b^2+4ac}}+\mathrm{C}.$$

Therefore, putting $\frac{1}{x}$ instead of y,

$$\int\frac{dx}{x\sqrt{-a+bx+cx^2}}=\frac{1}{\sqrt{a}}\cos^{-1}\frac{2a-bx}{x\sqrt{b^2+4ac}}+\mathrm{C}.$$

130. The formulæ investigated from articles 125 to 128 serve for the integration of innumerable differentials. Thus, from art. 125 we have

$$\int\frac{dx}{\sqrt{a+x^2}}=\mathrm{l.}\,(x+\sqrt{a+x^2})+\mathrm{C}$$
$$\int\frac{dx}{\sqrt{bx+x^2}}=\mathrm{l.}\,(\tfrac{1}{2}b+x+\sqrt{bx+x^2})+\mathrm{C};$$

and, from the first formula of art. 129,

$$\int\frac{adx}{x\sqrt{a^2+cx^2}}=\mathrm{l.}\,\frac{2a^2-2a\sqrt{a^2+cx^2}}{x}+\mathrm{C}$$
$$=\mathrm{l.}\,\frac{a-\sqrt{a^2+cx^2}}{x}+\mathrm{C}.$$

The second of these integrals is obtained from the first by passing l. $(2a)$ into the arbitrary constant C. It may yet have another form; for

$$\int\frac{2adx}{x\sqrt{a^2+cx^2}}=\mathrm{l.}\,\frac{(a-\sqrt{a^2+cx^2})}{-cx^2}+\mathrm{C}.$$

Now $-cx^2=(a+\sqrt{a^2+cx^2})\,(a-\sqrt{a^2+cx^2})$; therefore, substituting and reducing,

$$\int\frac{adx}{x\sqrt{a^2+cx^2}}=\tfrac{1}{2}\,\mathrm{l.}\,\frac{a-\sqrt{a^2+cx^2}}{a+\sqrt{a^2+cx^2}}+\mathrm{C}.$$

This example shows that the integral is much modified by the arbitrary constant which enters it.

131. Corresponding to these logarithmic integrals there is a set of similar integrals which are expressed by angles or arcs of a circle. Thus we have, art. 126,

$$\int\frac{dx}{\sqrt{a^2-x^2}}=\sin^{-1}\frac{x}{a}+\mathrm{C},$$
$$\int\frac{dx}{\sqrt{ax-x^2}}=\cos^{-1}\left(1-2\frac{x}{a}\right)+\mathrm{C},$$

and by formula 2 of art. 129,

$$\frac{adx}{x\sqrt{x^2-a^2}}=\sec^{-1}\frac{x}{a}+\mathrm{C}=\cos^{-1}\frac{a}{x}+\mathrm{C}.$$

132. As an example of the way of proceeding in the integration of a differential which involves radical quantities, let it be proposed to integrate the differential

$$\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}.$$

By an obvious transformation, we find

$$\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}=\frac{a^2dx}{x\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}$$
$$-\frac{xdx}{\{\sqrt{(a^2-x^2)(x^2-b^2)}\}}.$$

The first of these differentials may be otherwise expressed thus,

$$-\frac{a}{b}\,\frac{\frac{1}{x}\,d\left(\frac{1}{x}\right)}{\sqrt{\left\{\left(\frac{1}{a^2}-\frac{1}{x^2}\right)\left(\frac{1}{x^2}-\frac{1}{b^2}\right)\right\}}}.$$

Therefore we have

$$\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}=\frac{-xdx}{\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}$$
$$-\frac{a}{b}\,\frac{\frac{1}{x}\,d\left(\frac{1}{x}\right)}{\sqrt{\left\{\left(\frac{1}{a^2}-\frac{1}{x^2}\right)\left(\frac{1}{x^2}-\frac{1}{b^2}\right)\right\}}},$$

and it is evident that the two differentials have precisely the same form.

To integrate the first of these, let us assume

$$x^2=a^2\cos^2\varphi+b^2\sin^2\varphi;$$
$$\text{then } xdx=(b^2-a^2)\sin\varphi\cos\varphi\,d\varphi,$$
$$a^2-x^2=(b^2-a^2)\sin^2\varphi\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$
$$x^2-b^2=(b^2-a^2)\cos^2\varphi\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$
$$\frac{-xdx}{\sqrt{\{(a^2-x^2)(x^2-b^2)\}}}=\frac{(a^2-b^2)\cos\varphi\sin\varphi d\varphi}{(a-b^2)\cos\varphi\sin\varphi}=d\varphi.$$

Exactly in the same way, if we make

$$\frac{1}{x^2}=\frac{1}{a^2}\cos^2\psi+\frac{1}{b^2}\sin^2\psi,$$

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we get

$$\frac{1}{x}d\left(\frac{1}{x}\right)=\left(\frac{1}{b^2}-\frac{1}{a^2}\right)\sin\psi\cos\psi d\psi,$$

$$\frac{1}{a^2}-\frac{1}{x^2}=\left(\frac{1}{a^2}-\frac{1}{b^2}\right)\sin^2\psi\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$\frac{1}{x^2}-\frac{1}{b^2}=\left(\frac{1}{a^2}-\frac{1}{b^2}\right)\cos^2\psi\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$\frac{-\frac{1}{x}d\left(\frac{1}{x}\right)}{\sqrt{\left\{\left(\frac{1}{a^2}-\frac{1}{x^2}\right)\left(\frac{1}{x^2}-\frac{1}{b^2}\right)\right\}}}=\frac{\left(\frac{1}{b^2}-\frac{1}{a^2}\right)\sin\psi\cos\psi d\psi}{\left(\frac{1}{b^2}-\frac{1}{a^2}\right)\sin\psi\cos\psi}=d\psi.$$

On the whole, if φ and ψ be such angles that

$$\cos\varphi=\sqrt{\frac{x^2-b^2}{a^2-b^2}},\quad \cos\psi=\frac{a}{x}\cos\varphi;$$

then

$$\int\frac{dx}{x}\sqrt{\frac{a^2-x^2}{x^2-b^2}}=\varphi+\psi+\text{const.}$$

Integration of Binomial Differentials.

133. These differentials are represented by the formula

$$x^{m-1}dx\,(a+bx^n)^{\frac{q}{p}},$$

whose generality will not be affected by supposing that m and n are whole numbers. The object we propose is to find in what case this differential may be made rational.

We assume $a+bx^n=z^q$, so that $(a+bx^n)^{\frac{p}{q}}=z^p$; we then find

$$x^n=\frac{z^q-a}{b},\quad x^m=\left(\frac{z^q-a}{b}\right)^{\frac{m}{n}},$$

$$x^{m-1}dx=\frac{q}{nb}z^{q-1}\left(\frac{z^q-a}{b}\right)^{\frac{m}{n}-1};$$

and the proposed differential is now transformed into

$$\frac{q}{nb}z^{p+q-1}\,dz\left(\frac{z^q-a}{b}\right)^{\frac{m}{n}-1},$$

an expression which is evidently rational whenever $\frac{m}{n}$ is a whole number.

The differential $x^8dx\,(a+bx^3)^{\frac{p}{q}}$ satisfies this condition, since $m=9$, $n=3$, $\frac{m}{n}=3$, and it is transformed into

$$\frac{q}{3b}z^{p+q-1}\,dz\left(\frac{z^q-a}{b}\right)^2.$$

The differential $x^{m-1}\,dx\,(a+bx^n)^{\frac{p}{q}}$ admits of another form, by making the index of x between the brackets negative, or by dividing the quantity $a+bx^n$ by x^n; then we have

$$x^{m-1}dx\,(a+bx^n)^{\frac{p}{q}}=x^{m-1}\,dx\left\{(ax^{-n}+b)\,x^n\right\}^{\frac{p}{q}}$$

$$=x^{m+\frac{np}{q}-1}\,dx\,(ax^{-n}+b)^{\frac{p}{q}};$$

and by the process preceding, the last of these expressions may be made rational, whenever $\frac{m+\frac{np}{q}}{n}$ is a whole number; or, what is the same thing, whenever $\frac{m}{n}+\frac{p}{q}$ is an integer.

The differential $x^4\,dx\,(a+bx^3)^{\frac{1}{3}}$ is of this description, since $\frac{m}{n}=\frac{5}{3}$, $\frac{p}{q}=\frac{1}{3}$, $\frac{m}{n}+\frac{p}{q}=\frac{6}{3}=2$.

In applying to the differential

$$x^{m+\frac{np}{q}-1}\,dx\,(ax^{-n}+b)^{\frac{p}{q}},$$

the substitution indicated for the first form of this differential, we shall make $ax^{-n}+b=z^q$, and thence deduce $a+bx^n=x^n\,z^q$; and if we transform immediately the expression $x^{m-1}\,dx\,(a+bx^n)^{\frac{p}{q}}$ by means of the equation preceding, we shall evidently obtain the same result as if we had at first given it the form

$$x^{m+\frac{np}{q}-1}\,dx(ax^{-n}+b)^{\frac{p}{q}}.$$

134. Since it is not possible to integrate in every case the formula $x^{m-1}\,dx\,(a+bx^n)^{\frac{p}{q}}$, we may try to change it into another more simple, as has been done in integrating a differential (art. 115). We have found that $\int udv=uv-\int vdu$. If therefore we can decompose the differential into two factors, one of which being integrable, may be represented by dv, and the other by u, the integration of the proposed differential will be made to depend on that of vdu, which in some cases will be more simple than the proposed differential. This method, which is at once extensive and elegant, is called *integration by parts.*

For the sake of abridging, we shall write simply p instead of $\frac{p}{q}$, supposing p to represent a fractional number. The formula will then become

$$x^{m-1}\,dx\,(a+bx^n\ ^p.$$

Among the different ways of resolving this differential into factors, we choose this:

$$x^{m-n}\,x^{n-1}\,dx\,(a+bx^n)^p.$$

One of the factors, $x^{n-1}\,dx\,(a+bx^n)^p$, is integrable, whatever be the value of p (art. 108); representing it therefore by dv, we have

$$v=\frac{(a+bx\ )^{p+1}}{nb\,(p+1)},\text{ and }u=x^{m-n},$$

whence there results

$$\int x^{m-1}dx\,(a+bx^n)^p=\frac{x^{m-n}(a+bx^n)^{p+1}}{nb\,(p+1)},$$

$$-\frac{m-n}{nb\,(p+1)}\int x^{m-n-1}\,dx\,(a+bx^n)^{p+1};$$

but $\int x^{m-n-1}\,dx\,(a+bx^n)^{p+1}$

$$=\int x^{m-n-1}\,dx\,(a+bx^n)^p\,(a+bx^n)=$$

$$a\int x^{m-n-1}\,dx\,(a+bx)^p+$$

$$b\int x^{m-1}\,dx\,(a+bx^n)^p,$$

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putting this last in the preceding equation; and collecting the terms containing the integral $\int x^{m-1}dx(a+bx^n)^p$, we obtain, after reduction,

(A.)

$$\int x^{m-1}dx\,(a+bx^n)^p = \frac{x^{m-n}(a+bx^n)^{p+1}}{b\,(pn+m)}$$

$$-\frac{a\,(m-n)}{b\,(pn+m)}\cdot\int x^{m-n-1}dx\,(a+bx^n)^p.$$

It is obvious that since we may reduce the integration of $x^{m-1}dx\,(a+bx^n)^p$ to that of $x^{m-n-1}dx\,(a+bx^n)^p$, we may reduce this last to the integration of $x^{m-2n-1}dx\,(a+bx^n)^p$ by writing $m-n$ in the place of m in equation (A); then, by changing $m-n$ into $m-2n$, we shall be able to determine $\int x^{m-2n-1}dx\,(a+bx^n)^p$ by means of $\int x^{m-3n-1}dx\,(a+bx^n)^p$, and so on.

In general, if r denote the number of reductions, we shall at last come to $\int x^{m-rn-1}dx\,(a+bx^n)^p$, and the last formula will be

$$\int x^{m-(r-1)n-1}dx\,(a+bx^n)^p$$

$$=\frac{x^{m-rn}(a+bx^n)^{p+1}}{b\{pn+m-(r-1)n\}}-$$

$$\frac{a\,(m-rn)}{b\{pn+m-(r-1)n\}}\int x^{m-rn-1}dx\,(a+bx^n)^p.$$

It appears from this formula, that if m be a multiple of n, the integration of the proposed formula $x^{m-1}dx\,(a+bx^n)^p$ may be effected in algebraic terms, since the last integral of the transformed expression will be multiplied by $m-rn=0$. This result agrees with that of art. 133.

135. There is another way of reduction by which the exponent of the quantity within the parenthesis may be diminished by an unit; for this purpose it is only necessary to observe that

$$\int x^{m-1}dx(a+bx^n)^p$$

$$\int x^{m-1}dx(a+bx^n)^{p-1}(a+bx^n)$$

$$=a\int x^{m-1}dx(a+bx^n)^{p-1}$$

$$+\,b\int x^{m+n-1}dx(a+bx^n)^{p-1}.$$

Formula (A), by changing m into $m+n$, and p into $p-1$, gives

$$\int x^{m+n-1}dx(a+bx^n)^{p-1}=$$

$$\frac{x^m(a+bx^n)^p-am\int x^{m-1}dx(a+bx^n)^{p-1}}{b(pn+m)}.$$

Substituting this value in the preceding equation, we have

(B)

$$\int x^{m-1}dx(a+bx^n)^p=\frac{x^m(a+bx^n)^p}{pn+m}$$

$$+\frac{pna}{pn+m}\int x^{m-1}dx(a+bx^n)^{p-1}.$$

By this formula we may take away successively from p as many units as it contains; and by its application, along with formula (A), we may make the integral

$$\int x^{m-1}dx(a+bx^n)^p \text{ depend on}$$

$\int x^{m-rn-1}dx(a+bx^n)^{p-s}$, rn being the greatest multiple of m contained in $m-1$, and s the greatest whole number contained in p.

The integral $\int x^7dx(a+bx^3)^{\frac{5}{2}}$, for example, may be reduced by formula (A) successively to

$$\int x^4dx(a+bx^3)^{\frac{5}{2}},\ \int xdx(a+bx^3)^{\frac{5}{2}};$$

and by formula (B), $\int xdx(a+bx^3)^{\frac{5}{2}}$ is reduced to

$\int xdx(a+bx^3)^{\frac{3}{2}}$, and that again to $\int xdx(a+bx^3)^{\frac{1}{2}}$.

136. It is evident that if m and n were negative, the formulæ (A) and (B) would not accomplish the purpose for which they have been investigated; they would then increase the exponent of x without the parenthesis, as well as that of the parenthesis itself; but by reversing them we shall find others suited to the case in question. From formula (A) we deduce

$$\int x^{m-n-1}dx(a+bx^n)^p=\frac{x^{m-n}(a+bx^n)^{p+1}}{a(m-n)},$$

$$-\frac{b(m+np)}{a(m-n)}\int x^{m-1}dx(a+bx^n)^p.$$

In this expression, substitute $m+n$ in place of n, and it becomes

(C)

$$\int x^{m-1}dx(a+bx^n)^p=\frac{x^m(a+bx^n)^{p+1}}{am}$$

$$-\frac{b(m+n+np)}{am}\int x^{m+n-1}dx(a+bx^n)^p.$$

This formula diminishes the exponent without the parenthesis, since $m+n-1$ becomes $-m+n-1$ when $-m$ is put instead of $+m$.

To reverse the formula (B), we take

$$\int x^{m-1}dx(a+bx^n)^{p-1}=-\frac{x^m(a+bx^n)^p}{pna}$$

$$-\frac{m+np}{pna}\int x^{m-1}dx(a+bx^n)^p;$$

then we write $p+1$ instead of p, and thus find formula

(D)

$$\int x^{m-1}dx(a+bx^n)^p=-\frac{x^m(a+bx^n)^{p+1}}{na(p+1)}$$

$$-\frac{m+n+np}{na(p+1)}\int x^{m-1}dx(a+bx^n)^{p+1}.$$

This formula answers the proposed purpose, since $p+1$ becomes $-p+1$, when p is negative.

137. Let the formula be $\int\frac{x^{m-1}dx}{\sqrt{1-x^2}}$, where m is a whole positive number. Making $a=1$, $b=-1$, $n=2$, $p=-\frac{1}{2}$, we find

$$\int\frac{x^{m-1}dx}{\sqrt{1-x^2}}=-\frac{x^{m-2}\sqrt{1-x^2}}{m-1}+\frac{m-2}{m-1}\int\frac{x^{m-3}dx}{\sqrt{1-x^2}}.$$

Inverse Method.

Writing m in place of $m - 1$, we have

$$\int \frac{x^m dx}{\sqrt{1-x^2}} = -\frac{x^{m-1}\sqrt{1-x^2}}{m} + \frac{m-1}{m}\int \frac{x^{m-2}dx}{\sqrt{1-x^2}}.$$

If we give to m successive different values, beginning with the uneven numbers, we have

$$\int \frac{xdx}{\sqrt{1-x^2}} = -\sqrt{1-x^2} + \text{const.}$$

$$\int \frac{x^3dx}{\sqrt{1-x^2}} = -\tfrac{1}{3}x^2\sqrt{1-x^2} + \tfrac{2}{3}\int \frac{xdx}{\sqrt{1-x^2}},$$

$$\int \frac{x^5dx}{\sqrt{1-x^2}} = -\tfrac{1}{5}x^4\sqrt{1-x^2} + \tfrac{4}{5}\int \frac{x^3dx}{\sqrt{1-x^2}},$$

$$\int \frac{x^7dx}{\sqrt{1-x^2}} = \tfrac{1}{7}x^6\sqrt{1-x^2} + \tfrac{6}{7}\,\frac{x^5dx}{\sqrt{1-x^2}},$$

&c.

and hence we deduce

$$\int \frac{x^3dx}{\sqrt{1-x^2}} = -\left(\tfrac{1}{3}x^2 + \frac{1.2}{1.3}\right)\sqrt{1-x^2},$$

$$\int \frac{x^5dx}{\sqrt{1-x^2}} = -\left(\tfrac{1}{5}x^4 + \frac{1.4}{3.5}x^2 + \frac{1.2.4}{1.3.5}\right)\sqrt{1-x^2},$$

$$\int \frac{x^7dx}{\sqrt{1-x^2}} = -\left(\tfrac{1}{7}x^6 + \frac{1.6}{5.7}x^4 + \frac{1.4.6}{3.5.7}x^2 \right.$$
$$\left. + \frac{1.2.4.6}{1.3.5.7}\right)\sqrt{1-x^2},$$

&c.

The law of formation of the integrals is evident; an arbitrary constant is to be annexed to each.

Let us now consider the even values of m. Supposing $m = 2, 4, 6$, &c. we have

$$\int \frac{x^2dx}{\sqrt{1-x^2}} = -\tfrac{1}{2}x\sqrt{1-x^2} + \tfrac{1}{2}\int \frac{dx}{\sqrt{1-x^2}},$$

$$\int \frac{x^4dx}{\sqrt{1-x^4}} = -\tfrac{1}{4}x^3\sqrt{1-x^2} + \tfrac{3}{4}\int \frac{x^2dx}{\sqrt{1-x^2}},$$

$$\int \frac{x^6dx}{\sqrt{1-x^2}} = -\tfrac{1}{6}x^5\sqrt{1-x^2} + \tfrac{5}{6}\int \frac{x^4dx}{\sqrt{1-x^2}}.$$

&c.

Here all the integrals depend on

$$\int \frac{dx}{\sqrt{1-x^2}} = \sin^{-1} x + \text{const. (art. 23.)}$$

Let us call A the arc whose sine is x, and we have

$$\int \frac{dx}{\sqrt{1-x^2}} = \text{A} + \text{const.}$$

$$\int \frac{x^2dx}{\sqrt{1-x^2}} = -\tfrac{1}{2}x\sqrt{1-x^2} + \tfrac{1}{2}\text{A} + \text{const.}$$

$$\int \frac{x^4dx}{\sqrt{1-x^2}} = -\left(\tfrac{1}{4}x^5 + \frac{1.3}{2.4}x\right)\sqrt{1-x^3}$$
$$+ \frac{1.3}{2.4}\text{A} + \text{const.}$$

$$\int \frac{x^6dx}{\sqrt{1-x^2}} = -\left(\tfrac{1}{6}x^5 + \frac{1.5}{4.6}x^3 + \frac{1.3.5}{2.4.6}x\right)\sqrt{1-x^2}$$
$$+ \frac{1.3.5}{2.4.6}\text{A} + \text{const.}$$

138. Let us now consider the formulæ which answer to the case of m negative; then by formula (C) art. 136,

$$\int \frac{x^{-m-1}dx}{\sqrt{1-x^2}} = -\frac{x^{-m}\sqrt{1-x^2}}{m}$$
$$+ \frac{m-1}{m}\int \frac{x^{-m+1}dx}{\sqrt{1-x^2}}.$$

Writing $-m$ instead of $-m-1$, this becomes

$$\int \frac{dx}{x^m\sqrt{1-x^2}} = \frac{-\sqrt{1-x^2}}{(m-1)x^{m-1}}$$
$$+ \frac{m-2}{m-1}\int \frac{dx}{x^{m-2}\sqrt{1-x^2}}.$$

We cannot make $m = 1$, because that value would make the denominator *zero* and the co-efficient infinite. We have already found the integral in this case, viz.

$$\int \frac{dx}{x\sqrt{1-x^2}} = -\text{l.}\,\frac{1+\sqrt{1-x^2}}{x} + \text{const. (art. 130).}$$

Proceeding now, making $m = 3$, $m = 5$, &c. we have

$$\int \frac{dx}{x^3\sqrt{1-x^2}} = -\frac{\sqrt{1-x^2}}{2x^2} + \tfrac{1}{2}\int \frac{dx}{x\sqrt{1-x^2}},$$

$$\int \frac{dx}{x^5\sqrt{1-x^2}} = -\frac{\sqrt{1-x^2}}{4x^4} + \tfrac{3}{4}\int \frac{dx}{x^3\sqrt{1-x^2}},$$

$$\int \frac{d}{x^7\sqrt{1-x^2}} = -\frac{\sqrt{1-x^2}}{6x^6} + \tfrac{5}{6}\int \frac{dx}{x^5\sqrt{1-x^2}}.$$

&c.

Making $m = 2$, $m = 4$, $m = 6$, &c. we find

$$\int \frac{dx}{x^2\sqrt{1-x^2}} = -\frac{\sqrt{1-x^2}}{x} + \text{const.}$$

$$\frac{dx}{x^4\sqrt{1-x^4}} = -\frac{\sqrt{1-x^2}}{3x^3} + \tfrac{2}{3}\int \frac{dx}{x^2\sqrt{1-x^2}},$$

$$\frac{dx}{x^6\sqrt{1-x^6}} = -\frac{\sqrt{1-x^2}}{5x^5} + \tfrac{4}{5}\int \frac{dx}{x^4\sqrt{1-x^2}},$$

&c.

From these two series of equations we deduce, as in the former article, a series of differentials integrated by logarithms, and another by algebraic formulæ.

Integration by Series.

139. The integral $\int \text{X}\,dx$ is easily found when the function X is expanded into a series, because then we have only to integrate a series of single terms in succession, to which the rule of art. 104 immediately applies.

Thus, let $\text{X} = \text{A}x^m + \text{B}x^{m+n} + \text{C}x^{m+2n} + \text{D}x^{m+3n} +$ &c. If both members of this equation be multiplied by dx, and each term be separately integrated, we have

$$\int \text{X}\,dx = \frac{\text{A}x^{m+1}}{m+1} + \frac{\text{B}x^{m+n+1}}{m+n+1} + \frac{\text{C}x^{m+2n+1}}{m+2n+1} + \text{\&c.} + c.$$

If in the expansion of X any term of the form $\frac{\text{E}}{x}$ occur, the integral corresponding to that term will be E l. x (art. 20). We shall now give particular examples.

Ex. 1. To integrate $\frac{dx}{a+x}$ by a series.

We know that the integral comprehends in it Napier's logarithm of $a + x$ (art. 20). Now, by division,

$$\frac{1}{a+x} = \frac{1}{a} - \frac{x}{a^2} + \frac{x^2}{a^3} - \frac{x^3}{a^4} + \frac{x^5}{a^6} - \text{\&c.}$$

Therefore, multiplying by dx, and integrating,

$$\int \frac{dx}{a+x} = \frac{x}{a} - \frac{x^2}{2a^2} + \frac{x^3}{3a^3} - \frac{x^4}{4a^4} + \text{\&c.} + \text{C}.$$

This series expresses the general integral, without any regard to its particular application. If, however, we consider it as expressing l. $(a + x)$, then we have

$$\text{l.}\,(a+x)=\frac{x}{a}-\frac{x^2}{2a^2}+\frac{x^3}{3a^3}-\frac{x^4}{4a^4}+\&c.+C.$$

The constant quantity C is now no longer indeterminate; it must have such a value as satisfies this equation whatever be the value of x. If we make $x=0$, then all the terms of the series vanish, and we have $\text{l.}\,a=C$.

Thus the value of C is determined, and we have

$$\text{l.}\,(a+x)=\text{l.}\,a+\frac{x}{a}-\frac{x^2}{2a^2}+\frac{x^3}{3a^3}-\&c.$$

This result agrees with what we found (art. 86).

Ex. 2. To integrate $\frac{dx}{1+x^2}$ by a series. By division,

$$\frac{1}{1+x^2}=1-x^2+x^4-x^6+\&c.$$

Multiplying now both sides of this equation by dx, and integrating, we have

$$\int\frac{dx}{1+x^2}=x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\&c.+C.$$

As a formula purely analytical, the constant C must be regarded as indeterminate. We know, however, that $\frac{dx}{1+x^2}$ is the integral of an arc of which x is the tangent, the radius being unity (art. 22, Ex. 3). Therefore, if we mean to express $\tan^{-1}x$ by a series, then

$$\tan^{-1}x=x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\&c.+C.$$

The constant C has now a precise value, and it may be found by giving any corresponding known values to $\tan-x$ and x. Now we know that when $\tan^{-1}x=0$, then $x=0$. Therefore, considering that when all the terms in the series vanish, we have $0=0+C$; thus it appears that $C=0$.

Ex. 3. In the last example, the integral of $\frac{dx}{1+x^2}$ was expressed by a series of terms formed from the ascending powers of x. We may, however, express that integral by a descending series. By division

$$\frac{1}{x^2+1}=\frac{1}{x^2}-\frac{1}{x^4}+\frac{1}{x^6}-\&c.$$

$$\text{And}\int\frac{dx}{x^2+1}=-\frac{1}{x}+\frac{1}{3x^3}-\frac{1}{5x^5}+\&c.+C.$$

If we now regard the integral as the angle or arc whose tangent is x, we have

$$\tan^{-1}x=\frac{-1}{x}+\frac{1}{3x^3}-\frac{1}{5x^5}+\&c.+C.$$

The value of C cannot now be found by making $x=0$, because then the arc $=0$, and the substitution of $x=0$ makes all the terms of the series infinite. If we suppose the arc to be a quadrant $=\frac{\pi}{2}$, then x is infinite, and the terms of the series are each $=0$; by this assumption, $\frac{1}{2}\pi=C$. We have now

$$\tan^{-1}x=\tfrac{1}{2}\pi-\frac{1}{x}+\frac{1}{3x^3}-\frac{1}{5x^5}+\&c.$$

Ex. 4. The differential of the arc whose sine is x is $\frac{dx}{\sqrt{1-x^2}}$. It is proposed to integrate this differential by a series.

By the binomial theorem, $\frac{1}{\sqrt{1-x^2}}=(1-x^2)^{-\frac{1}{2}}=$

$$1+\tfrac{1}{2}x^2+\frac{1.3}{2.4}x^4+\frac{1.3.5}{2.4.6}x^6+\frac{1.3.5.7}{2.4.6.8}x^8+\&c.$$

Hence we have $\sin^{-1}x=\int\frac{dx}{\sqrt{1-x^2}}=$

$$x+\frac{1x^3}{2.3}+\frac{1.3x^5}{2.4.5}+\frac{1.3.5x^7}{2.4.6.7}+\&c.$$

When the arc $=0$, then the sine $=0$; therefore both sides of this equation vanish together, and no constant is wanted to adjust it to equality.

140. The object of integration by series being to obtain approximate values of the integrals when they cannot be found accurately, it is important to have several series, so that we may be able to choose one convergent for a proposed value of x. Ascending series, or those which proceed by positive and increasing powers of x, do not converge sufficiently unless x be a small fraction, as happens with the series of Ex. 2; whilst those which proceed by the negative powers of x, or descending series, converge only so as to be of use when x is a large number.

141. In having recourse to series, it is sufficient to find one, of which the terms are separately integrable, although each may not have the form $Ax^{\frac{m}{n}}dx$; they may have any form, the integral of which can be expressed by an algebraic quantity, or a logarithm, or an arc of a circle; or, in short, any function, the numerical value of which is most readily obtained, provided always that the convergency be such as to admit of the sum of all the terms which are not taken in being rejected, because of its smallness in comparison to the sum of the terms taken in.

In the application of the calculus recourse is only to be had to series as a last resource, when the integral, from its nature, cannot be found in finite terms, or by logarithms or arcs of a circle, which in fact are the sums of infinite series. Indeed it would be very convenient to have various other tables, ready computed, of the value of a function corresponding to given successive values of the variable. The labour of their computation, their necessary great extent, and the infrequency of their use, have hitherto limited this valuable aid in calculation to a table of Napier's Logarithms, in addition to the Trigonometrical Tables.

Integration of Logarithmic Functions.

142. Let it be required to integrate $Pdx\,(\text{l.}\,x)^n$, that is, the nth power of Napier's logarithm of x multiplied by Pdx, P being an algebraic function of x. Here we apply the formula $\int udv=uv-\int vdu$; and making $u=(\text{l.}\,x)^n$, from which we find $du=n\,(\text{l.}\,x)^{n-1}\frac{dx}{x}$, also $dv=Pdx$, we have, making in order to abridge $\int Pdx=N$,

$$\int Pdx\,(\text{l.}\,x)^n=N\,(\text{l.}\,x)^n-n\int\frac{dx}{x}\,(\text{l.}\,x)^{n-1}N.$$

If now we represent the integral $\int\frac{dx}{x}N$ by M, we shall have

$$\int\frac{dx}{x}N(\text{l.}\,x)^{n-1}=M\,(\text{l.}\,x)^{n-1}-(n-1)\int\frac{dx}{x}(\text{l.}\,x)^{n-2}M.$$

By this reduction the proposed integral is made to depend on another of the same kind, in which the exponent of the logarithm is an unit less. Thus, if $P=x^m$, we have

$$\int x^m dx\,(\text{l.}\,x)^n=\frac{x^{m+1}}{m+1}(\text{l.}\,x)^n-\frac{n}{m+1}\int(\text{l.}\,x)^{n-1}x^m dx.$$

By applying the formula to this last integral, and again to the result, we find $\int x^m dx\, (\mathrm{l}.\, x)^n =$

$$x^{m+1}\left\{\frac{(\mathrm{l}.\, x)^n}{m+1} - \frac{n(\mathrm{l}.\, x)^{n-1}}{(m+1)^2} + \frac{n(n-1)\,(\mathrm{l}.\, x)^{n-2}}{(m+1)^3} - \&\mathrm{c.}\right\} + \mathrm{C}.$$

It is evident that this will always terminate when n is a whole number.

143. If n be a whole negative number, we must apply the formula $\int udv = uv - \int vdu$ so as to increase the exponent of the logarithm. Thus in the differential

$$\frac{\mathrm{P}dx}{(\mathrm{l}.\, x)^n} = \frac{\mathrm{P}x}{-n+1} \cdot (-n+1)\,(\mathrm{l}.\, x)^{-n}\ \frac{dx}{x},$$

we make $\mathrm{P}x = u$, and $(\mathrm{l}.\, x)^{-n}\,\dfrac{dx}{x} = dv$, by which $\dfrac{(\mathrm{l}.\, x)^{-m+1}}{-n+1} = v$; for then we have $\displaystyle\int \frac{\mathrm{P}dx}{(\mathrm{l}.x)^n} =$

$$\frac{\mathrm{P}x}{-n+1}\,(\mathrm{l}.\, x)^{-n+1} + \frac{1}{n-1}\int (\mathrm{l}.\, x)^{-n+1}\, d\,(\mathrm{P}x).$$

Let us suppose $\mathrm{P} = x^m$, then this formula becomes

$$\int \frac{x^m dx}{(\mathrm{l}.\, x)^n} = \frac{-x^{m+1}}{(n-1)\,(\mathrm{l}.\, x)^{n-1}} + \frac{m+1}{n-1}\int \frac{x^m dx}{(\mathrm{l}.\, x)^{n-1}}.$$

By repetitions of this transformation, we at last make the proposed integral depend on $\displaystyle\int \frac{x^m dx}{\mathrm{l}.\, x}$. Now, put $x^{m+1} = z$, then $\mathrm{l}.\, x = \dfrac{\mathrm{l}.\, z}{m+1}$ and $x^m dx = \dfrac{dz}{m+1}$, therefore

$$\frac{x^m dx}{\mathrm{l}.\, x} = \frac{dz}{\mathrm{l}. z}.$$

The integral of this last quantity is a transcendental of a peculiar kind, which cannot be otherwise expressed than by infinite series.

Integration of Exponential Functions.

144. It appears from art. 19, that $d(a^x) = \mathrm{l}.\,(a)\, a^x\, dx$, therefore

$$\int a^x dx = \frac{a^x}{\mathrm{l}.\, a} + \mathrm{C}.$$

And because $dx = \dfrac{d(a^x)}{a^x\, \mathrm{l}.a}$; therefore, if V be any algebraic function of a^x, then, putting $a^x = u$, we have $\mathrm{V}dx = \dfrac{\mathrm{V}du}{u\,\mathrm{l}.a}$, an expression which, in respect of u, has an algebraic form.

For example, let $\mathrm{V} = \dfrac{a^x}{\sqrt{1+a^{nx}}}$, then,

$$\int \frac{a^x dx}{\sqrt{1+a^{nx}}} = \frac{du}{\mathrm{l}.\, a\sqrt{1+u^n}}.$$

The integral of this last expression may be found by rules which have been investigated.

Let z be any function of x, then, e being the number of which Nap. log $= 1$, we have $d(ze^x) = e^x dz + e^x\, zdx$, therefore

$$\int e^x\, dx\left(z + \frac{dz}{dx}\right) = ze^x + \mathrm{C}.$$

For example, let $z = x^3 - 1$, then $\dfrac{dz}{dx} = 3x^2$, and

$$\int e^x dx(3x^2 + x^3 - 1) = e^x\,(x^3 - 1) + \mathrm{C}.$$

145. In other cases we may have recourse to the method of integration by parts (art. 134). Thus, let the differential be $x^n a^x\, dx$, then, by the formula $\int udv = uv - \int vdu$, making $u = x^n$, $dv = a^x dx$, we find

$$\int a^x x^n dx = \frac{a^x x^n}{\mathrm{l}.\, a} - \frac{n}{\mathrm{l}.\, a}\int a^x x^{n-1} dx.$$

By treating the differential $a^x x^{n-1} dx$ in the same way, and repeating this as often as necessary, we find $\int a^x x^n dx =$

$$a^x\left\{\frac{x^n}{\mathrm{l}.\, a} - \frac{nx^{n-1}}{(\mathrm{l}.\, x)^2} + \frac{n(n-1)\,x^{n-2}}{(\mathrm{l}.\, a)^3} - \ldots \pm \frac{1\,.\,2\,.\,3\ldots n}{(\mathrm{l}.\, a)^{n+1}}\right\} + \mathrm{C}.$$

146. If the exponent n be negative, by following the same method we may increase the exponent of x. Accordingly, from the formula $\int udv = uv - \int vdu$, making $u = a^x$, and $dv = \dfrac{dx}{x^n}$, we find

$$\int \frac{a^x\, dx}{x^n} = \frac{-a^x}{(n-1)\,x^{n-1}} + \frac{\mathrm{l}.\, a}{n-1}\int \frac{a^x\, dx}{x^{n-1}}.$$

By repeating this transformation, we bring the integral $\displaystyle\int \frac{a^x\, dx}{x^n}$ to depend at last on $\displaystyle\int \frac{a^x\, dx}{x}$.

If we make $a^x = z$, then $x\ \mathrm{l}.\, a = \mathrm{l}.\, z$, and $x = \dfrac{\mathrm{l}.\, z}{\mathrm{l}.\, a}$, and $dx = \dfrac{1}{\mathrm{l}.\, a}\,\dfrac{dz}{z}$; hence $\dfrac{a^x\, dx}{x} = \dfrac{1}{\mathrm{l}.\, a}\,\dfrac{dz}{\mathrm{l}.\, z}$, and

$$\int \frac{a^x\, dx}{x} = \frac{1}{\mathrm{l}.\, a}\int \frac{z}{\mathrm{l}.\, z}.$$

These two integrals involve the same difficulty, and have greatly exercised the ingenuity of analysts. It appears they can only be integrated by infinite series. See on this subject, Lacroix, *Traité du Calcul Differentiel*, vol. iii. No. 1224.

147. If n be a fraction, either of the preceding methods will apply to reduce the exponent of x to some fraction between 0 and $+ 1$ or $- 1$; and then recourse must be had to the method of infinite series.

Whatever has been done in regard to the integral of $x^n a^x dx$, will apply to $\mathrm{P}a^x dx$, supposing P to be any function of x whatever.

Integration of Angular or Circular Functions.

148. There are several ways of integrating expressions which contain circular or trigonometrical functions of a variable.

METHOD I.—Let x be an arc whose sine or cosine is z; for example, let $\sin x = z$, then

$$\cos x = \sqrt{1 - z^2},\ dx = \frac{dz}{\sqrt{1 - z^2}},$$

$$dx \sin^m x \cos^n x = z^m\,(1 - z^2)^{\frac{n-1}{2}}\, dx.$$

1. If n be any odd number, then, in the binomial differential, the radical in the transformed expression disappears.

2. If m is an odd number, the exponent of z without the parenthesis, when increased by unity, will be a multiple of z its exponent, within the parenthesis. Thus one of the conditions of art. 132 is satisfied, and the differential may be made rational.

3. If m and n are even numbers, then the second condition of art. 132 will be satisfied, and the differential may be integrated.

As an example, let the differential be $dx \sin^3 x$. This, by making $z = \sin x$, becomes $\frac{z^3\,dz}{\sqrt{1-z^2}}$. Now, by art. 137,

$$\int \frac{z^3\,dz}{\sqrt{1-z^2}} = \tfrac{1}{3}\cos x\,(2+\sin^2 x) + \mathrm{C}.$$

149. Method II.—The powers of the sine or cosine may be transformed into series, of which the terms are sines or cosines of the multiples of the arc; the terms to be integrated will then have the form $dx \cos kx$, $dx \sin kx$. Now

$$\int dx \cos kx = \frac{1}{k}\sin kx + \mathrm{C};$$

$$\int dx \sin kx = -\frac{1}{k}\cos kx + \mathrm{C}.$$

Ex. 1. Let the differential be $dx \cos^5 x$. By the calculus of sines (Algebra, 258), $\cos^5 x = \frac{1}{16}(\cos 5x + 5\cos 3x + 10\cos x)$; therefore

$\int dx \cos^5 x = \frac{1}{80}\sin 5x + \frac{5}{48}\sin 3x + \frac{5}{8}\sin x + \mathrm{C}.$

This method is often used, because the sines and cosines of the multiples of an arc are more easily found than the powers of the sine and cosine.

Ex. 2. Let the differential be $dx \cos^2 x \sin^3 x$. In the first place, we have (Algebra, art. 260),

$\cos^2 x \sin^3 x = \frac{1}{16}(-\sin 5x + \sin 3x + 2\sin x).$

Hence, multiplying by dx, and integrating,

$\int dx \cos^2 x \sin^3 x = \frac{1}{80}\cos 5x - \frac{1}{48}\cos 3x - \frac{1}{16}\cos x + \mathrm{C}.$

150. Method III.—It has been found (Algebra, art. 270), that e being the base of Napier's logarithms,

$$\cos x = \frac{e^{x\sqrt{-1}} + e^{-x\sqrt{-1}}}{2};$$

$$\sin x = \frac{e^{x\sqrt{-1}} - e^{x\sqrt{-1}}}{2\sqrt{-1}}.$$

These exponential expressions for the sine and cosine enable us to transform differentials containing circular functions into others involving exponential and logarithmic functions, and to integrate by the methods explained (art. 140–145).

151. Method IV.—We may reduce the integration of such a differential as $\sin^m x \cos^n x\, dx$, to that of another in which the indices of the sine or cosine are smaller numbers, by the formula $\int u\,dv = uv - \int v\,du$. For, making $u = \sin^{m-1} x$ and $dv = dx \sin x \cos^n x$, we find $v = -\frac{\cos^{n+1} x}{n+1}$, and

$$\int dx \sin^m x \cos^n x = -\frac{\sin^{m-1}}{n+1} x \cos^{n+1} x$$
$$+ \frac{m-1}{n+1}\int dx \cos^{n+2} x \sin^{m-2} x.$$

From this expression, by putting for $\cos^{n+1} x$, its value $\cos^n x\,(1-\sin^2 x)$, and transposing, we find

(α)

$$\int dx \sin^m x \cos^n x = -\frac{\sin^{m-1} x \cos^{n+1} x}{m+n}$$
$$+ \frac{m-1}{m+1}\int dx \sin^{m-2} x \cos^n x.$$

By resolving the proposed differential into the two factors $dx \cos x \sin^{mx}$ and $\cos^{n-1} x$, and proceeding in the same way, we find

(β)

$$\int dx \sin^m x \cos^n x = \frac{\sin^{m+1} x \cos^{n-1} x}{m+n}$$
$$+ \frac{n-1}{m+n}\int dx \sin^m x \cos^{n-2} x.$$

One of these formulæ serves to depress the exponent of the sine, and the other that of the cosine, and by their joint application the differential may be found when m and n are two positive integer numbers. For example,

$\int dx \sin^3 x \cos^2 x = -\frac{1}{5}\sin^2 x \cos^3 x + \frac{2}{5}\int dx \sin x \cos^2 x,$

$\int dx \sin x \cos^2 x = \frac{1}{3}\sin^2 x \cos x + \frac{1}{3}\int dx \sin x;$

this last term $= -\frac{1}{3}\cos x + \mathrm{C}$, after collecting the terms, we have $\int dx \sin^3 x \cos^2 x =$

$\cos x\,(-\frac{1}{5}\sin^2 x \cos^2 x + \frac{2}{15}\sin^2 x - \frac{2}{15}) + \mathrm{C}.$

152. When m and n are negative, these formulæ require some modification. The first, by changing m into $-n$, gives

(γ)

$$\int \frac{dx \sin^m x}{\cos^n x} = -\frac{\sin^{m-1} x}{(m-n)\cos^{n-1} x}$$
$$+ \frac{m-1}{m-n}\int \frac{dx \sin^{m-2} x}{\cos^n x}.$$

This makes the integral sought depend on that of $\frac{dx \sin x}{\cos^n x}$ or $\frac{dx}{\cos^n x}$, according as m is odd or even. By making $\cos x = z$, the first of these becomes $-\frac{dz}{z^n}$, of which the integral is obvious. The integral of the other will be shown presently in art. 153.

The second of the two general formulæ, by making n negative, and bringing the integral in the second side of the equation to stand alone, and lastly, changing n into $n-2$, gives

(δ)

$$\int \frac{dx \sin^m x}{\cos^n x} = \frac{\sin^{m+1} x}{(n-1)\cos^{n-1} x}$$
$$- \frac{m-n+2}{n-1}\int \frac{dx \sin^m x}{\cos^{n-2} x}.$$

By this the integral sought is reduced to that of $dx \sin^m x$, or to $\frac{dx \sin^m x}{\cos x}$, according as n is even or odd. The first is found by formula (α) (art. 151), the other is presently to be noticed.

153. If we make m or $n = 0$, we have

$$\int dx \sin^m x = \frac{-\cos x \sin^{m-1} x}{m} + \frac{m-1}{m}\int dx \sin^{m-2} x,$$

$$\int dx \cos^n x = \frac{\sin x \cos^{n-1} x}{n} + \frac{n-1}{n}\int dx \cos^{n-2} x,$$

$$\int \frac{dx}{\sin^m x} = \frac{-\cos x}{(m-1)\sin^{m-1} x} + \frac{m-2}{m-1}\int \frac{dx}{\sin^{m-2} x}$$

$$\int \frac{dx}{\cos^n x} = \frac{\sin x}{(n-1)\cos^{n-1} x} + \frac{n-2}{n-1}\int \frac{dx}{\cos^{n-2} x}.$$

154. When the exponents of the sine and cosine are both negative, we multiply the numerator by $\cos^2 x + \sin^2 x = 1$, and have

Inverse Method.

$$\int\frac{dx}{\sin^m x\cos^n x}=\int\frac{dx}{\sin^{m-2}x\cos^n x}+\int\frac{dx}{\sin^m x\cos^{n-2}x},$$

fractions with sin x or cos x in the denominator.

If $m=n$, then because $\sin x\cos x=\frac{1}{2}\sin 2x$, by making $2x=z$, the fraction takes the form of the third of the preceding formulæ.

155. We shall conclude this branch of the subject by integrating four of the more elementary circular functions.

1. To integrate $\frac{dx}{\sin x}$. We observe that $\sin x=2\sin\frac{1}{2}x\cos\frac{1}{2}x$, therefore,

$$\frac{dx}{\sin x}=\frac{dx}{2\sin\frac{1}{2}x\cos\frac{1}{2}x}=\frac{1}{2}\frac{dx\sec^2\frac{1}{2}x}{\tan\frac{1}{2}x}=\frac{d.\tan\frac{1}{2}x}{\tan\frac{1}{2}x},$$

$$\text{and}\int\frac{dx}{\sin x}=\text{l.}\left(\tan\tfrac{1}{2}x\right)+\text{C}.$$

2. To integrate $\frac{dx}{\cos x}$. Putting $\frac{1}{2}\pi$ to denote an arc of 90°, and $x=\frac{1}{2}\pi-z$, we have $dx=-dz$, $\cos x=\sin z$, and

$$\int\frac{dx}{\cos x}=\int\frac{-dz}{\sin z}=-\text{l.}\tan\tfrac{1}{2}z=\text{l.}\frac{1}{\tan\frac{1}{2}z}+\text{C}.$$

Now $\frac{1}{\tan\frac{1}{2}z}=\frac{1}{\tan(\frac{1}{4}\pi-\frac{1}{2}x)}=\tan\left(\frac{1}{4}\pi+\frac{1}{2}x\right)$.

Therefore $\int\frac{dx}{\cos x}=\text{l.}\tan\left(\frac{1}{4}\pi+\frac{1}{2}x\right)+\text{C}$.

This and the preceding integral may be otherwise expressed thus,

$$\int\frac{dx}{\sin x}=\tfrac{1}{2}\text{l.}\frac{1-\cos x}{1+\cos x}+\text{C}.$$

$$\int\frac{dx}{\cos x}=\tfrac{1}{2}\text{l.}\frac{1+\sin x}{1-\sin x}+\text{C}.$$

3. $\int\frac{dx}{\tan x}=\int\frac{dx\cos x}{\sin x}=\text{l.}(\sin x)+\text{C}.$

4. $\int dx\tan x=\int\frac{dx\sin x}{\cos x}=\text{l.}\frac{1}{\cos x}+\text{C}.$

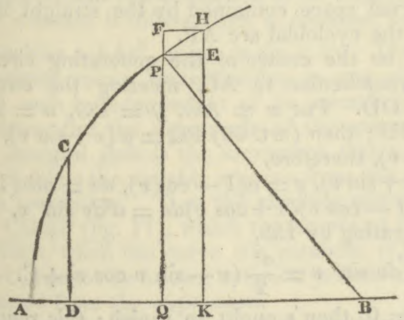
Applications of the Integral Calculus.

Before we proceed farther in the explanation of the theory of the calculus, we shall apply its principles to some of the more important problems in Geometry.

Quadrature of Curves.

156. Let $\text{AQ}=x$, $\text{PQ}=y$, be the co-ordinates of a curve, of which AB is the axis; and let the area CDQP, comprehended between CD, an ordinate given in position, and PQ any other ordinate, be denoted by s. We have found (art. 69) that $ds=ydx$; therefore, in any curve whatever,

Fig. 21.



$$\text{area } s=\int ydx$$

Ex. 1. Let the curve be a parabola, of which p is the parameter. By the nature of the curve, $y^2=px$, and $y=p^{\frac{1}{2}}x^{\frac{1}{2}}$, and $ydx=p^{\frac{1}{2}}x^{\frac{1}{2}}dx$; therefore, taking the integral by art. 104,

$$s=\int ydx=\tfrac{2}{3}p^{\frac{1}{2}}x^{\frac{3}{2}}+c=\tfrac{2}{3}yx+\text{C}\ldots\ldots\ldots(1)$$

Let $\text{AD}=a$, $\text{CD}=b$; when $s=0$, then $x=a$, $y=b$. These values being substituted in the above general expression for the area, it becomes

$$0=\tfrac{2}{3}ab+\text{C}.$$

If we now subtract the sides of equation (2) from the corresponding sides of (1), the indeterminate constant C will disappear, and we shall have

$$s=\tfrac{2}{3}(xy-ab).$$

This is a convenient way of eliminating the indeterminate constant. If A, the origin of the abscissa x, be the vertex of the parabola, and if the area s be supposed to begin at the vertex, then $a=0$, $b=0$; and the area comprehended between the axis, an ordinate, and the curve, is $\frac{2}{3}xy$, that is, $\frac{2}{3}$ of the circumscribing parallelogram.

Ex. 2. Let the curve be a circle Apa (see fig. 7, art. 66), of which Aa is a diameter. Suppose the origin of co-ordinates to be at O, the centre; let Ob be the radius perpendicular to OA; put $\text{OQ}=x$, $p\text{Q}=y$, OA the radius $=a$, the space $\text{OQ}pb=s$; by the nature of the circle $x^2+y^2=a^2$, and $y=\sqrt{a^2-x^2}$; hence

$$s=\int ydx=\int dx\sqrt{a^2-x^2}.$$

This integral cannot be expressed in finite algebraic terms; therefore recourse must be had to an infinite series. By the binomial theorem, $\sqrt{a^2-x^2}=(a^2-x^2)^{\frac{1}{2}}=$

$$a-\frac{1\,.\,x^2}{2\,.\,a^2}-\frac{1\,.\,1\,.\,x^4}{2\,.\,4\,a^3}-\frac{1\,.\,1\,.\,3\,.\,x^6}{2\,.\,4\,.\,6\,a^5}-\text{\&c.}$$

Each term of this series being multiplied by dx, and the integral taken, we have

$$s=ax-\tfrac{1}{2}\cdot\frac{x^3}{3a}-\frac{1.1}{2.4}\cdot\frac{x^5}{5a^3}-\frac{1.1.3}{2.4.6}\cdot\frac{x^7}{5a^5}-\text{\&c.}+\text{C}.$$

To determine C, we consider that when $x=0$, then $s=0$, these values make both sides of the equation $=0$; therefore $\text{C}=0$; when $x=a$, then $s=\frac{1}{4}$ of the area of the circle; therefore the area of a circle whose radius $=a$ is

$$4a^2\left(\frac{1}{1}-\frac{1}{2}\cdot\frac{1}{3}-\frac{1.1}{2.4}\cdot\frac{1}{5}-\frac{1.1.3}{2.4.6}\cdot\frac{1}{7}-\text{\&c.}\right).$$

This series converges slowly, so that a considerable number of terms would be required to give its value near the truth. If we make $x=\cos$ arc 60°, then, drawing the radius Op, the area OQpb will manifestly be made up of the sector POb, which is $\frac{1}{12}$ of the area of the circle, and the triangle OQp, which is $\frac{1}{2}\text{OQ}\,.\,p\text{Q}=\frac{\sqrt{3}}{8}a^2$.

Putting $\frac{a}{2}$ for x in the series, it will now converge much faster, and the sum of seven of its terms will be $\cdot4783057a^2$, from which subtracting $\frac{\sqrt{3}}{8}a^2=\cdot2165063a^2$, there remains $\cdot2617994a^2$ for $\frac{1}{12}$ of the area, and $3\cdot1415928a^2$ for the whole area of the circle. We have found this number by a less laborious calculation, in ALGEBRA, 273. We may make A, one end of the diameter (fig. 7, art. 66), the origin of the co-ordinates, so that $\text{AQ}=x$, $pq=y$, segment ApQ$=s$ · then, because $y=\sqrt{2ax-x^2}$, the area

$$s=\int dx\sqrt{2ax-x^2}=\int dx\sqrt{2ax}\left(1-\frac{x}{2a}\right)^{\frac{1}{2}}.$$

The integral of this expression will be had by converting $\left(1-\frac{x}{2a}\right)^{\frac{1}{2}}$ into a series, then multiplying the terms separately by $dx\sqrt{2ax}$, and integrating.

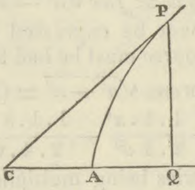
Ex. 3. To find the area of the elliptic segment APQ (fig. 7, art. 66). Let OA, the semitransverse, $=a$, OB, the semiconjugate, $=b$, $\text{AQ}=x$, $\text{PQ}=y$, the area $\text{APQ}=s$. By the nature of the ellipse, $y=\frac{b}{a}\sqrt{2ax-x^2}$; therefore the elliptic segment

$$s=\int ydx=\frac{b}{a}\int dx\sqrt{2ax-x}.$$

Let APa be a semicircle on the same axis, and let s' denote the segment cut off by the ordinate pPQ, which is common to both curves. We found in last example that $s'=\int dx\sqrt{2ax-x^2}$; therefore $s=\frac{b}{a}s'$. Thus it appears that the area of APQ, any segment of an ellipse, has to the area of ApQ the corresponding segment of the circumscribing circle, the constant ratio of the lesser axis to the greater. Neither of the integrals require a constant, because both vanish when $x=0$.

Ex. 4. To find the area of the hyperbolic sector PCA, C being the centre of the hyperbola, and CA the semitransverse axis.

Fig. 22.



Draw the ordinate PQ; let the semitransverse axis $\text{CA}=a$, the semiconjugate axis $=b$, $\text{CQ}=x$, $\text{PQ}=y$, the sector $\text{PAC}=s$.

Because $s=$ triangle CPQ — space APQ $=\frac{1}{2}xy-\int ydx$; therefore $ds=\frac{1}{2}xdy+\frac{1}{2}ydx-ydx=\frac{1}{2}(xdy-ydx)$.

Now, by the nature of the curve, $y=\frac{b}{a}\sqrt{x^2-a^2}$, therefore $dy=\frac{b}{a}\frac{xdx}{\sqrt{x^2-a^2}}$, and

$$ds=\frac{b}{2a}\left\{\frac{x^2dx}{\sqrt{x^2-a^2}}-dx\sqrt{x^2-a^2}\right\}=\frac{1}{2}ab\frac{dx}{\sqrt{x^2-a^2}}.$$

Now, by art. 130, $\int\frac{dx}{\sqrt{x^2-a^2}}=\text{l.}\,(x+\sqrt{x^2-a^2})+\text{C}$.

$$\text{Therefore } s=\frac{ab}{2}\,\text{l.}\,(x+\sqrt{x^2-a^2})+\text{C}.$$

Here C denotes an indefinite constant: To determine its value, we consider that when $x=a$, then $s=0$; therefore in this particular case,

$$0=\frac{ab}{2}\,\text{l.}\,a+\text{C}.$$

Hence, by subtracting equals from equals, and observing that the difference of two logarithms is the logarithm of their quotient, we eliminate C, and have

$$s=\frac{ab}{2}\,\text{l.}\,\frac{x+\sqrt{x^2-a^2}}{a}.$$

Because $\sqrt{x^2-a^2}=\frac{ay}{b}$, therefore also

$$s=\frac{ab}{2}\,\text{l.}\left\{\frac{x}{a}+\frac{y}{b}\right\}.$$

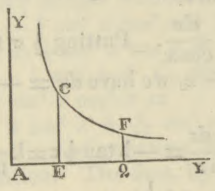
Ex. 5. To find the area of s, the hyperbolic space APQ' we have $s=$ triangle CPQ — sector CAP, or

$$s=\tfrac{1}{2}xy-\frac{ab}{2}\,\text{l.}\left\{\frac{x}{a}+\frac{y}{b}\right\}.$$

Ex. 6. Let the curve be an equilateral hyperbola, of which AX, AY are the asymptotes: To find s, the area included by the hyperbolic arc CF, the straight lines CE, FQ, which are parallel to one asymptote, and EQ, the segment of the other asymptote between them; suppose CE one of the parallels to be given in position. Put $\text{AE}=a$, $\text{EC}=b$, $\text{AQ}=x$, $\text{EQ}=y$. By the nature of the curve, $xy=ab$; hence $y=\frac{ab}{x}$, and

$$s=ydx=ab\frac{dx}{x}=ab\,\text{l.}\,x+\text{C}.$$

Fig. 23.



Now, when $x=a$, then $s=0$; in this case $0=ab\,\text{l.}\,a+\text{C}$, or $\text{C}=-ab\,\text{l.}\,a$; hence, substituting for C its value, and putting $\text{l.}\,\frac{x}{a}$ for $\text{l.}\,x-\text{l.}\,a$, we have

$$s=ab\,\text{l.}\,\frac{x}{a}.$$

From this formula we find $\text{l.}\,\frac{x}{a}=\frac{s}{ab}$. Thus it appears that Napier's logarithm of any number $\frac{x}{a}$ may be expressed by a hyperbolic area; hence it has happened that the logarithms of his system have been called *hyperbolic.*

If M be the *modulus* of any system, the log of $\frac{x}{a}$ in that system will be $\text{M l.}\,\frac{x}{a}$; therefore, in any system of which the modulus is M, we have

$$\log.\,\frac{x}{a}=\frac{\text{M}}{ab}\,s.$$

Thus we see that logarithms of any system may be expressed geometrically by hyperbolic areas, and therefore that the name *hyperbolic logarithms* cannot with propriety be given to one kind of logarithms rather than to another.

Ex. 7. Let the curve be the cycloid (fig. 9, art. 66), of which AC is the axis, and AH a perpendicular to the axis at the vertex A. From any point in the curve draw PG perpendicular to AH: it is proposed to find s, the area of the external space contained by the straight lines AG, GP, and the cycloidal arc AP.

Let O be the centre of the generating circle; draw PDQ perpendicular to AC, meeting the circle in D, and join OD. Put $x=\text{AG}$, $y=\text{PG}$, $a=\text{AO}$, $v=$ angle AOD; then (art. 66) $\text{PQ}=a(v+\sin v)$, $\text{AQ}=a(1-\cos v)$, therefore,

$x=a(v+\sin v)$, $y=a(1-\cos v)$, $dx=adv(1+\cos v)$,
$ds=a^2(1-\cos v)(1+\cos v)dv=a^2dv\sin^2 v$,
and integrating by 153,

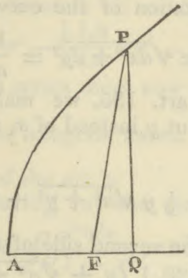
$$s=a^2\int dv\sin^2 v=\frac{a^2}{2}(v-\sin v\cos v)+\text{C}.$$

When $v=0$, then s ought to vanish; this requires that $\text{C}=0$. Putting now the arc AD for av, and $\text{DQ}\cdot\text{OQ}$ for $a^2\sin v\cos v$, we have

$$s=\tfrac{1}{2}\,\text{AO}\cdot\text{arc AD}-\tfrac{1}{2}\,\text{DQ}\cdot\text{OQ}=\text{circ. seg. ADQ}.$$

Ex. 8. To find the area contained by AF, a line drawn from the focus of a parabola to the vertex, FP a line drawn to any point of the curve, and the intercepted arc AP.

Fig. 24.



Let a denote the parameter $= 4\text{AF}$, $u =$ the angle AFP, $r = \text{FP}$, $s =$ the parabolic sector APF. Draw PQ perpendicular to the axis AF. By the nature of the curve, $\text{PF} = \text{AQ} + \text{AF}$. Now, supposing PFA to be an obtuse angle, $\text{FQ} = -r \cos v$, $\text{AQ} = \frac{1}{4}a - r\cos v$, $\text{AF} = \frac{1}{4}a$, therefore, $r = \frac{1}{2}a - r\cos v$, and $r(1+\cos v) = \frac{1}{2}a$; hence, since $1 + \cos v = 2\cos^2 \frac{1}{2}v$, $r = \frac{a}{4}\,\frac{1}{\cos^2 \frac{1}{2}v}$.

Now, by formula 3, article 69, $ds = \frac{1}{2}r^2 dv$, therefore

$$ds = \frac{a^2}{16}\,\frac{\frac{1}{2}dv}{\cos^4\frac{1}{2}v}.$$

To integrate this differential, we consider that

$$\frac{\frac{1}{2}dv}{\cos^2\frac{1}{2}v} = \sec^2\tfrac{1}{2}v\,\frac{dv}{2} = d(\tan\tfrac{1}{2}v);$$

and that $\frac{1}{\cos^2\frac{1}{2}v} = \sec^2\frac{1}{2}v = 1 + \tan^2\frac{1}{2}v$;

therefore, multiplying these equations, we get

$$\frac{\frac{1}{2}dv}{\cos^4\frac{1}{2}v} = d(\tan\tfrac{1}{2}v) + \tan^2\tfrac{1}{2}v\; d(\tan\tfrac{1}{2}v);$$

and hence, integrating by the rule art. 104, we find

$$\int\frac{\frac{1}{2}dv}{\cos^4\frac{1}{2}v} = \tan\tfrac{1}{2}v + \tfrac{1}{3}\tan^2\tfrac{1}{2}v + \text{C}.$$

Observing now that when $v = 0$, then $s = 0$; therefore $\text{C} = 0$, and we have

$$s = \frac{a^2}{16}(\tan\tfrac{1}{2}v + \tfrac{1}{3}\tan^3\tfrac{1}{2}v).$$

This integral might have been found by the formula of art. 153; not so easily, however. The formula here found is wanted in the astronomy of comets.

157. Since the area of any plane curve is expressed by an integral $\int ydx$, in which y the ordinate is some function of x the absciss, so, on the other hand, any integral may be represented geometrically by the area of a curve. The geometrical representation of an integral shows distinctly wherein it differs from a common analytic function, such as $a + bx^n$, or ax, or $\sin x$, &c. These last have determinate values corresponding to any given value of x, and each is independent of its preceding and following values; but the magnitude of the space represented by an integral $\int ydx$ is the increment that a certain area receives while the variable x passes from one state of magnitude to another. Thus the absolute magnitude of the space CDQP (fig. 11), which represents an integral $\int ydx$, and which, when the curve is a parabola, is expressed by $\frac{2}{3}xy + \text{C}$, cannot be known before C is determined, or else eliminated from the expression.

Whatever be the nature of the curve, the integral $\int ydx =$ space CPQD is correctly indicated, so as to admit of being computed, when we say that it is generated while the variable x increases from any value $=$ AD, to another value $=$ AQ, the lines AD, AQ being supposed given in magnitude, and the relation between x and y known. The same thing is briefly indicated by this notation:

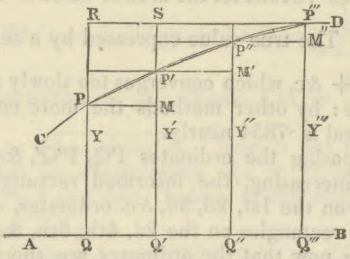
$$\text{area CPQD} = \int_a^x ydx,$$

in which a and x denote the lines AD and AQ.

From what has been shown it appears that an integral is an indeterminate quantity, the result of a change in the value of its variable; and that to know its absolute value we must know the values of the variable at its commencement and completion.

158. The analogy between a curvilineal area and an integral indicates a general method of finding its numerical value to any degree of nearness. Supposing y to be any function of x, let it be proposed to find the integral $\int ydx$ between $x = a$ and $x = b$.

Fig. 25.



Let CPD be a curve, of which the co-ordinates are x and y. In the axis AB, take $\text{AQ} = a$, the least value of x, and $\text{AQ}''' = b$, its greatest value, and draw the ordinates PQ, P'''Q'''. The area PQQ'''P''' will be the geometrical expression of the integral between the proposed limits; and by whatever means that area can be found, the same will apply to the determination of the integral.

Divide QQ''' into any number of equal parts at the points Q′, Q″, &c. and draw the ordinates P′Q′, P″Q″, &c. These will divide the whole figure into the spaces PP′Q′Q, P′P″Q″Q′, &c. Let a series of rectangles PQ′, P′Q″, P″Q''' be formed, each having the least of two adjoining ordinates for a side: these will fall within the curve, supposing it to be entirely concave or convex towards the axis. Let another series P′Q, P″Q′, P'''Q″ be constructed, each having the longest of two adjoining ordinates for a side: the aggregate of these will exceed the area of the curve. The length of the base of each rectangle will be known, and, from the nature of the curve, its height will also be known; hence the areas of all the rectangles may be found. The sum of the areas of the inscribed rectangles will be less than the integral, and the sum of the areas of the circumscribing rectangles will be greater. The difference between these sums is the rectangle PMSR, which, by supposing its base $\text{PM} = \text{QQ}'$ to be sufficiently small, may be less than any assignable space. Thus an approximate value of the integral may be found, which shall differ from the truth by as small a quantity as we please.

Draw the chords PP′, P′P″, P″P''', thus forming a series of trapeziums, which will differ from the curvilineal area by less than the sum of either the inscribed or circumscribing parallelograms, and will be a mean between them. This will be a nearer approximation than either sum to the integral.

As an example of the application of this method, let it be proposed to approximate to the integral $\int_0^1 \frac{dx}{1+x^2}$, that is, to the arc whose tangent is x, between the values of $x = 0$ and $x = 1$, which arc is $\frac{1}{4}$ of a semicircle, the radius being supposed $= 1$. In this case the equation of the curve is $y = \frac{1}{1+x^2}$. Let us suppose the base QQ‴ to be divided into ten equal parts; then, making $x = 0$, $x = \cdot 1$, $x = \cdot 2$, &c. to $x = 1$, we obtain eleven equidistant ordinates or values of y as follows:

The 1*st*,	1.00000	The 7*th*,	·73529
2*d*,	·99010	8*th*,	·67114
3*d*,	·96154	9*th*,	·60975
4*th*,	·91743	10*th*,	·55249
5*th*,	·86207	11*th*,	·50000
6*th*,	·80000		

By the elements of geometry, the area of the rectilineal figure formed by the trapeziums is found by adding together all the ordinates except the first and last, and half the sum of the first and last, and multiplying the result by the common breadth of the trapeziums, which is ·1. This gives ·784981 for the area or value of the integral $\int_0^1 \frac{dx}{1+x^2}$. The true value expressed by a series is $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} +$ &c. which converges too slowly to be of any practical use: by other methods the more correct value of the integral is ·7854 nearly.

159. Supposing the ordinates PQ, P′Q′, &c. to go on continually increasing, the inscribed rectangles will be constructed on the 1st, 2d, 3d, &c. ordinates, and the circumscribing rectangles on the 2d, 4th, 6th, &c.

Observing now that the ordinates are the values of y corresponding to AQ, AQ′, &c. values of x, which differ by the common interval QQ′, we have manifestly the following rule for approximating to an integral $\int ydx$ between the limits of $x = \mathrm{AQ} = a$ and $x = \mathrm{AQ}''' = b$. Divide the interval $\mathrm{QQ}''' = b - a$ into n equal parts, each equal to h.

Find Y, Y′, Y″, ... $\mathrm{Y}^{(n)}$ the particular values of Y corresponding to $x = a$, $x = a + h$, $x = a + 2h \ldots$; $x = a + nh = b$.

Then, supposing the ordinates to go on increasing,

$$\int_a^b ydx > h\,(\mathrm{Y} + \mathrm{Y}' + \mathrm{Y}'' \ldots\ldots + \mathrm{Y}^{(n-1)});$$

$$\int_a^b ydx < h\,(\mathrm{Y}' + \mathrm{Y}'' + \mathrm{Y}''' \ldots\ldots + \mathrm{Y}^{(n)}).$$

The difference of these is $h(\mathrm{Y}^{(n)} - \mathrm{Y})$, which, by taking x sufficiently small, may be as small as we please. We may reason in the same way when the ordinates form a decreasing series. If they first increase and then decrease, the interval $b - a$ may be divided into two or more portions, such that y increases or decreases continually from one end of each to the other.

Whatever be the values of y, provided they be always finite from $x=a$ to $x=b$, putting for them Y, Y′, Y″ .. $\mathrm{Y}^{(n)}$, we have

$$\int_a^b ydx \,. = \mathrm{Y}h + \mathrm{Y}'h + \mathrm{Y}''h \ldots\ldots + \mathrm{Y}^{n-1}\,h.$$

Leibnitz and his followers considered the integral $\int ydx$ as the sum of the infinitely little elements Yh, Y′h, &c. Hence the origin of the terms integral, to integrate, integration, &c. When h is infinitely little, and represented by dx, the differential of x, then ydx is the differential of the integral.

Rectification of Curves.

160. We have found (art. 72) that z being any arc of a curve referred to an axis by rectangular co-ordinates x, y, the differential of the arc, viz. $dz, = \sqrt{dx^2 + dy^2}$. We are now to apply the calculus to particular curves.

Ex. 1. Let the curve be a parabola (fig. 16) of which the parameter $= 2a$, the absciss $\mathrm{AQ} = x$, the ordinate $\mathrm{PQ} = y$. The equation of the curve, $2ax = y^2$, gives

$$adx = ydy \text{ and } dz = \sqrt{dx^2 + dy^2} = \frac{1}{a} dy \sqrt{a^2 + y^2}.$$

If in formula B, art. 135, we make $m = 1$, $n = 2$, $p = \frac{1}{2}$, $b = 1$, and put y instead of x, and a^2 instead of a, we have

$$\int dy \sqrt{a^2 + y^2} = \tfrac{1}{2}\, y \sqrt{a^2 + y^2} + \tfrac{1}{2}\, a^2 \int \frac{dy}{\sqrt{a^2 + y^2}}.$$

The integral in the second side of this equation is, by the formula of art. 130, $\mathrm{l.}\,(y + \sqrt{a^2 + y^2}) + \mathrm{C}$; therefore $z = \frac{y}{2a} \sqrt{a^2 + y^2} + \frac{a}{2}\,\mathrm{l.}\,(y + \sqrt{a^2 + y^2}) + \mathrm{C}$.

If we suppose z to begin at the vertex, then, when $z = 0$, $y = 0$; therefore $\mathrm{C} = -\frac{a}{2}\,\mathrm{l.}\,a$, and

$$z = \frac{y}{2a}\sqrt{a^2 + y^2} + \frac{a}{2}\,\mathrm{l.}\,\frac{y + \sqrt{a^2 + y^2}}{a}.$$

Ex. 2. Let the curve be the second cubic parabola of which the equation is $y^3 = ax^2$. In this case the general formula gives

$$dz = dy \sqrt{1 + \frac{9y}{4a}} \text{ and } z = \tfrac{8}{27} \sqrt{\left(1 + \frac{9y}{4a}\right)^3} + \mathrm{C}.$$

This curve is perfectly rectifiable. Indeed it is the evolute of the parabola (art. 81, ex. 1).

Ex. 3. Let the curve be a circle (fig. 7), of which the radius $\mathrm{OA} = a$. Reckoning the co-ordinates from the centre, let $\mathrm{OQ} = x$, $p\mathrm{Q} = y$, $b\mathrm{P} = z$. The equation of the curve is $x^2 + y^2 = a^2$; hence $y = \sqrt{a^2 - x^2}$, $dy = -\frac{xdx}{\sqrt{a^2 - x^2}}$ and $dz = \frac{adx}{\sqrt{a^2 - x^2}}$. This integral cannot be otherwise expressed than by an infinite series. We have already found it (art. 139, ex. 4) on the supposition that the radius $= 1$; when the radius $= a$, we have only to put $\frac{x}{a}$ instead of x, thence we get

$$z = x + \frac{1}{2} \cdot \frac{x^3}{3a^2} + \frac{1.3}{2.4} \cdot \frac{x^5}{5a^4} + \frac{1.3.5}{2.4.6} \frac{x^7}{7a^6} + \&c.$$

There is no constant wanted; because, from the nature of the case, z and x begin together.

From this example, also from ex. 2, art. 156, and ex. 2, art. 139, it appears that the quadrature, also the rectification of the circle, is equivalent to the determination of any one of these integrals, $\int dx \sqrt{1 - x^2}$, $\int \frac{dx}{\sqrt{1 - x^2}}$, $\int \frac{dx}{1 + x^2}$, which is a problem in pure analysis, and which does not seem to admit of a solution in finite terms. The solution of that celebrated geometrical problem is therefore hopeless.

Ex. 4. Let the curve be an ellipse (fig. 7), of which the semitransverse axis $\mathrm{OA} = 1$, the semiconjugate $\mathrm{OB} = b$, the eccentricity, which is $\sqrt{1. - b^2}, = e$. Let O the centre be the origin of the co-ordinates $\mathrm{OQ} = x$, $\mathrm{PQ} = y$; and, reckoning the arc from the extremity of the lesser axis, let $\mathrm{BP} = z$. By the nature of the curve, $y = b\sqrt{1 - x^2}$, therefore $dy = \frac{-bxdx}{\sqrt{1 - x^2}}$, and

$$dz = \sqrt{dx^2 + dy^2} = \frac{dx\sqrt{1 - (1 - b^2)x^2}}{\sqrt{1 - x^2}} = \frac{dx\sqrt{1 - e^2x^2}}{\sqrt{1 - x^2}}.$$

The integral of this differential is of such a nature as not to admit of being expressed either by arcs of a circle or logarithms. Therefore it can only be expressed by infinite series.

By the binominal theorem $\sqrt{1 - e^2x^2} =$

$$1 - \tfrac{1}{2} e^2x^2 - \frac{1.1}{2.4} e^4x^4 - \frac{1.1.3}{2.4.6} e^6x^6 - \frac{1.1.3.5}{2.4.6.8} e^8x^8 - \&c.$$

The terms of this series must now be multiplied each by $\frac{dx}{\sqrt{1 - x^2}}$, and the integrals found, and their sum will express the length of the arc z.

The integrals, leaving out the numeral co-efficients, will all have the form $\int \frac{x^{2n}dx}{\sqrt{1 - x^2}}$; therefore they will be found by the second formula of article 137. Thus, putting φ for the arc whose sine is x, we have

$$\int \frac{dx}{\sqrt{1 - x^2}} = \varphi,$$

$$\int \frac{x^2dx}{\sqrt{1 - x^2}} = -\tfrac{1}{2} x \sqrt{1 - x^2} + \tfrac{1}{2} \varphi,$$

$$\int \frac{x^4dx}{\sqrt{1 - x^2}} = -\left(\tfrac{1}{4} x^3 + \frac{1.3}{2.4} x\right)\sqrt{1 - x^2} + \frac{1.3}{2.4} \varphi,$$

&c.

These integrals being multiplied by their respective coefficients, we have the elliptic arc $z =$

$$\varphi\left(1 - \frac{1.1}{2.2} e^2 - \frac{1.1.3}{2.2.4.4} e^4 - \frac{1.1.3.3.5}{2.2.4.4.6.6} e^6 - \&c.\right)$$
$$+ \tfrac{1}{2} e^2 \left(\tfrac{1}{2} x \sqrt{1 - x^2}\right)$$
$$+ \frac{1.1}{2.4} e^4 \left(\tfrac{1}{4} x^3 + \frac{1.3}{2.4} x\right)\sqrt{1 - x^2}$$
$$+ \frac{1.1.3}{2.4.6} e^6 \left(\tfrac{1}{6} x^5 + \frac{1.3}{4.6} x^3 + \frac{1.3.5}{2.4.6} x\right)\sqrt{1 - x^2}$$
$$+ \&c.$$

Here no constant is wanted, because the functions on both sides of $=$ vanish when $x = 0$, as they should.

If we make $x = 1$, then all the terms multiplied by $\sqrt{1-x^2}$ vanish; and as in this case $\varphi =$ a quadrant $= \frac{1}{2} \pi$, we get the elliptic quadrant AB $=$

$$\tfrac{1}{2} \pi \left(1 - \frac{1.1}{2.2} e^2 - \frac{1.1.3}{2.2.4.4} e^4 - \frac{1.1.3.3.5}{2.2.4.4.6.6} e^6 - \&c.\right)$$

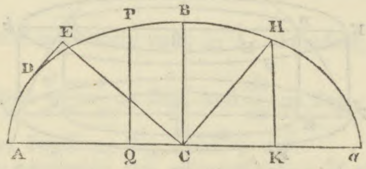
This expression converges pretty fast when e is small, but when e is nearly $= 1$, it is hardly of any use. To have a complete solution, we ought to have another series suited to the case of $e = 1$ nearly. Our limits, however, do not admit of our entering on its investigation here. The integration of the differential $\frac{dx\sqrt{1 - e^2x^2}}{\sqrt{1 - x^2}}$, which, putting φ for the arc whose sine $= x$, may be also expressed thus, $d\varphi\sqrt{1 - e^2 \sin^2 \varphi}$, has greatly engaged the attention of mathematicians. On this subject consult the works quoted in the conclusion of our History of Fluxions, page 640.

The length of a hyperbolic arc may be found exactly in the same way as that of the ellipse from its equation $y = b\sqrt{x^2 - 1}$.

161. We shall here explain the remarkable property of the ellipse, first discovered by Fagnano, as has been mentioned, page 640, and which has proved the fertile germ of some of the finest discoveries in the modern analysis.

In the ellipse ABa, let DE be a tangent at any point D in the curve, draw CE from the centre perpendicular to the tangent, and parallel to it draw the semidiameter CH, which will be the conjugate to that drawn from C through D; and draw HK perpendicular to the axis. Let CA $= 1$, CB $= b$, $\sqrt{1 - b^2}$, the eccentricity, $= e$. Make the perpendicular CE $= p$, the tangent DE $= t$, the angle ACE $=$ CHK $= \varphi$, and the arc AD $= z'$. By the nature of the ellipse, $CA^2 \cdot HK^2 = CB^2 (CA^2 - CK^2)$, that is, because HK $=$ CH $\cos \varphi$, and CK $=$ CH $\sin \varphi$, $CH^2 \cos^2 \varphi = b^2(1 - CH^2 \sin^2 \varphi)$, and hence $b^2 = CH^2 (\cos^2 \varphi + b^2 \sin^2 \varphi) = CH^2 (1 - e^2 \sin^2 \varphi)$, and $CH = \frac{b}{\sqrt{1 - e^2 \sin^2 \varphi}}$.

Fig. 26.



Now, by the nature of the ellipse, $CH = \frac{CA \cdot CB}{CE} = \frac{b}{p}$, therefore $p = \sqrt{1 - e^2 \sin^2 \varphi}$. Now it has been shown (art. 75) that in every curve $d(z + t) = pd\varphi$, and therefore $z + t = \int pd\varphi$; hence, in the ellipse, $z' + t = \int \varphi\sqrt{1 - e^2 \sin^2 \varphi}$.

In the semi-axis CA take CQ $=$ CA $\cdot \sin$ ECA $= \sin \varphi$, draw the ordinate QP, and put $z =$ elliptic arc BP. By what was shown in last article, $dz = d\varphi \sqrt{1 - e^2 \sin^2 \varphi}$, and $z = \int d\varphi \sqrt{1 - e^2 \sin^2 \varphi}$; thence it appears that the functions $z' + t$ and z have the same differential, therefore they can only differ by a constant, that is, $z' + t = z + C$. Now when $z = 0$, then $\varphi = 0$, and $z' = 0$, also $t = 0$; therefore the variables z, z', and t' begin together, and the constant $C = 0$; thus we have $z' + t = z$ and $z - z' = t$. Hence we have this very remarkable property of an ellipse. At any point D in the curve draw a tangent DE, and from the centre C draw CE perpendicular to the tangent. In CA take CQ $=$ CA $\cdot \sin$ ECA; draw the ordinate PQ. *The difference of the elliptic arcs* BP, AD (*that is*, BP — AD), *is equal to the tangent* DE. *This is in substance Fagnano's theorem. Hence it follows that any arc of an ellipse being given, another may be found by a geometrical construction, such, that their difference shall be an assignable straight line.*

We have found (art. 75) that in all curves $t = \frac{-dp}{d\varphi}$. In the ellipse $p = \sqrt{1 - e^2 \sin^2 \varphi}$ and $\frac{dp}{d\varphi} = \frac{-e^2 \sin \varphi \cos \varphi}{\sqrt{1 - e^2 \sin^2 \varphi}}$. Therefore, without any reference to the length of the tangent,

$$z - z' = \frac{e^2 \sin \varphi \cos \varphi}{\sqrt{1 - e^2 \sin^2 \varphi}}.$$

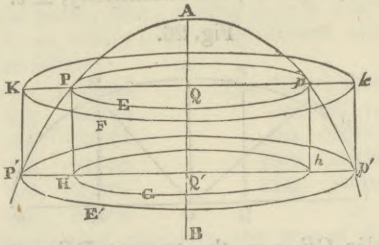
There are corresponding properties of the hyperbola, but our limits forbid our entering on them.

Cubature of Solids.

162. Let AB be the axis of any plane curve APP′, and PQ, P′Q′ ordinates perpendicular to the axis; draw PH perpendicular to the ordinate P′Q′, and PK perpendicular to PQ. Conceive now the plane figure AP′Q′ to revolve about the axis AB; the curve AP will generate a solid AP′E′p', called a *solid of revolution*; and the rectangles

PQQ′H, P′Q′QK will generate cylinders whose bases are circles PEp, P′E′p', and common altitude QQ′.

Fig. 27.



Put AQ $= x$, AQ′ $= x'$, PQ $= y$, P′Q′ $= y'$; the solid generated by the space APQ $= s$, that generated by AP′Q′ $= s'$. Let $\pi = 3{\cdot}1416 =$ the area of a circle whose radius is 1. The content of the cylinder whose base is PEp will be $\pi(x' - x)y^2$, and that of the cylinder whose base is P′E′p' will be $\pi(x' - x)y'^2$.

The solid generated by the curvilineal space PQQ′ ′ being greater than the cylinder whose base is PEp, but less than the cylinder whose base is P′E′p', we have

$$s' - s > \pi(x' - x)y^2, \text{ and } s' - s < \pi(x' - x)y'^2;$$

$$\text{therefore } \frac{s' - s}{x' - x} > \pi y^2, \text{ and } \frac{s' - s}{x - x} < \pi y'^2.$$

Conceive now the circle P′E′p' to approach continually to the circle PEp; they will ultimately coincide and be equal; therefore πy^2 is the limit of $\frac{s' - s}{x' - x}$, and consequently $\frac{ds}{dx} = \pi y^2$, and

$$ds = \pi y^2 dx, \text{ and } s = \pi \int y^2 dx.$$

By this formula the content of a solid of revolution generated by any given plane curve may be found.

163. Ex. 1. Let the solid be a paraboloid generated by the revolution of a parabola AP about its axis AQ. By the nature of the curve, $y^2 = ax$; therefore, in this case,

$$s = \pi \int ax dx = \tfrac{1}{2}\pi ax^2 + \mathrm{C} = \tfrac{1}{2}\pi xy^2 + \mathrm{C}.$$

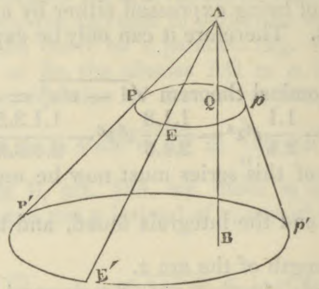
If the integral begin when $x = 0$, then also $s = 0$ and $\mathrm{C} = 0$; now πxy^2 is the content of a cylinder having the same base as the paraboloid, therefore, *a paraboloid is half a cylinder of the same base and altitude.*

From this geometrical theorem we may find the content of the solid between two sections of a paraboloid by planes perpendicular to its axis, which is called a *frustum* of a paraboloid. Let A be the area of the base of the frustum, a the area of its top, h its height, x the segment of the axis between the vertex of the paraboloid and top of the frustum. The content of the whole paraboloid $= \frac{1}{2}(x+h)\mathrm{A}$, and the content of the part cut off $= \frac{1}{2}xa$, therefore the content of the frustum $= \frac{1}{2}(x\mathrm{A} + h\mathrm{A} - xa)$. Now by the nature of the solid $\frac{x+h}{x} = \frac{\mathrm{A}}{a}$, hence $x\mathrm{A} - xa = ha$, therefore the content of the frustum is $\frac{1}{2}(\mathrm{A}+a)h$. Hence it appears that a frustum of a paraboloid is equal to a cylinder of the same altitude, and whose base is a mean between the top and bottom of the frustum.

Ex. 2. Let the solid be a cone whose vertex is A, and base P′E′p', a plane figure of any kind.

Let AB be the altitude of the cone, and PEp a section parallel to the base, meeting AB in Q. Let $b =$ the area of the base P′E′p', $v =$ area of section PEp, $c =$ AB, $x =$ AQ, $s =$ content of solid A-PEp. In this case, $ds = vdx$, an expression the same as for a solid of revolution, and found in the same way. Now, sections of similar cones are proportional to the squares of their like dimensions; therefore $c^2 : x^2 = b : v$, hence $v = \frac{bx^2}{c^2}$ and $ds = \frac{b}{c^2}x^2 dx$, and by integration $s = \frac{bx^3}{3c^2} + \mathrm{C} = \frac{vx}{3} + \mathrm{C}$. If x and s begin together, then $\mathrm{C} = 0$ and $s = \frac{1}{3}vx$. Thus it appears that *a cone of any kind is $\frac{1}{3}$ of its circumscribing cylinder.*

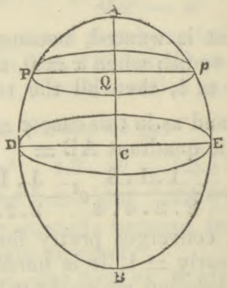
Fig. 28.



To find the content of a frustum of a cone, or space between the base and a plane parallel to its base; put $\mathrm{A} =$ area of base, $a =$ area of top, $h =$ height of frustum, $x =$ height of cone cut off above the frustum. The content of the whole cone $= \frac{1}{3}(h + x)\mathrm{A}$, and the content of the part cut off $= \frac{1}{3}xa$, therefore the content of the frustum $= \frac{1}{3}(h\mathrm{A} + x\mathrm{A} - xa) = \frac{1}{3}h\mathrm{A} + \frac{1}{3}x(\mathrm{A} - a)$. Now $\frac{\mathrm{A}}{a} = \frac{(x+h)^2}{x^2}$, and $\frac{\sqrt{\mathrm{A}}}{\sqrt{a}} = \frac{x+h}{x}$, hence $x = \frac{\sqrt{a}}{\sqrt{\mathrm{A}} - \sqrt{a}}h$, and $x(\mathrm{A} - a) = \sqrt{a}(\sqrt{\mathrm{A}} + \sqrt{a})h = (\sqrt{\mathrm{A}a} + a)h$. On the whole, the content of the frustum $= \frac{1}{3}(\mathrm{A} + a + \sqrt{\mathrm{A}a})h$.

Ex. 3. To find the content of a spheroid generated by the revolution of an ellipse about either of its axes.

Fig. 29.



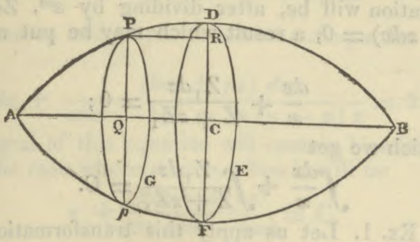
Let PQp be a section of the solid perpendicular to the fixed axis AB. Put AB $= a$, the revolving axis DE $= b$, also AQ $= x$, PQ $= y$. From the nature of the ellipse, $y^2 = \frac{b^2}{a^2}(ax - x^2)$, hence $s = \frac{\pi b^2}{a^2}\int(ax - x^2)dx = \frac{\pi b^2}{a^2}(\frac{1}{2}ax^2 - \frac{1}{3}x^3) + \mathrm{C}$.

If we suppose $s = 0$ when $x = 0$, then $\mathrm{C} = 0$. If we make $x = a$, then s, the whole spheroid, $= \frac{ab^2\pi}{6} = \frac{2}{3}a \times$ area of middle section. Hence it appears that *the whole solid is $\frac{2}{3}$ of its circumscribing cylinder.* This proposition was discovered by Archimedes.

If the axes a, b, be supposed equal, the solid is a sphere; hence it appears that the content of a sphere $= \frac{\pi}{6}a^3$, a being the diameter.

Ex. 4. Let the solid be a parabole spindle which is generated by the revolution of APB, an arc of a parabola, about ACB, an ordinate to its axis. From P any point in

Fig. 30.



the revolving curve, draw PQ perpendicular to the ordinate AB, and PR perpendicular to the axes of the parabola. Make DC $= p$, AC $= q$, CQ = PR $= x$, PQ = CR $= y$, the solid (between the sections DEF, PGp) $= s$. By the nature of the curve, $\text{PR}^2 : \text{AC}^2 = \text{DR} : \text{DC}$; that is, $x^2 : q^2 = p - y : p$; hence $p\,x^2 = pq^2 - q^2\,y$, and $y^2 = \frac{p^2}{q^4}(q^4 - 2q^2x^2 + x^4)$, and

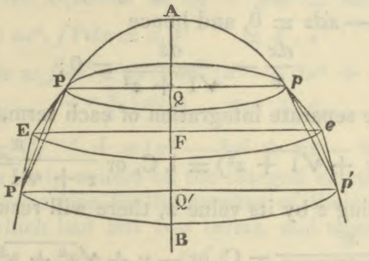
$$s = \frac{p^2\pi}{q^4}\int(q^4dx - 2q^2x^2dx + x^4dx)$$
$$= \frac{p^2\pi}{q^4}(q^4x - \tfrac{2}{3}q^2x^3 + \tfrac{1}{5}x^5) + \text{C}.$$

If the integral begin when $x = 0$, then $\text{C} = 0$. If we make $x = q$, we get $\frac{8}{15}p^2.q\pi$ for half the content of the solid generated by the curve ADB.

Surfaces of Solids.

164. Let AB be the axis of any plane curve APP′, and PQ, P′Q′ ordinates to the axis; draw PE, P′E tangents to the curve at P and P′, meeting in E; draw EF perpendicular to AB, and draw the chord PP′. Suppose now the curve to revolve about its axis AB; the arc APP′ will generate a curve surface, to be found; the portion PP′ of the arc will generate an increment of that surface, which, by an axiom in geometry, will be less than the sum of the conical surfaces generated by the tangents PE, P′E, but greater than the conical surface generated by the chord PP′. Put AQ $= x$, AQ′ $= x'$, PQ $= y$, P′Q′ $= y'$, EF $= y''$, arc AP $= z$, arc AP′ $= z'$, surface generated by arc AP $= v$, surface generated by arc AP′ $= v'$.

Fig. 31.



By the elements of geometry, the surfaces generated by the tangents PE P′E will be

$$\pi(\text{PQ} + \text{EF})\,\text{PE} = \pi(y + y'')\,\text{PE},$$
$$\pi(\text{P'Q'} + \text{EF})\,\text{P'E} = \pi(y' + y'')\,\text{P'E},$$

and the surface generated by the chord PP′ will be

$$\pi(\text{PQ} + \text{P'Q'})\,\text{PP'} = \pi(y + y')\,\text{PP'}.$$

Therefore $v' - v < \pi\{(y + y'')\,\text{PE} + (y' + y'')\,\text{P'E}\}$,

$$v' - v > \pi(y + y')\text{ chord PP'},$$

and $$\frac{v' - v}{z' - z} < \pi\frac{(y + y'')\,\text{PE} + (y' + y'')\,\text{P'E}}{\text{arc P'P}},$$

$$\frac{v' - v}{z' - z} > \pi(y + y')\frac{\text{chord P'P}}{\text{arc P'P}}.$$

Now, the point P being supposed to approach to P′, these quantities, one of which is greater than $\frac{v' - v}{z' - z}$, and the other less, become ultimately equal; for the lines y, y'', y' become equal, and $(y + y'')\,\text{PE} + (y + y'')\,\text{PE}$ becomes $(y' + y)(\text{PE} + \text{P'E})$, and the fractions $\frac{\text{PE} + \text{P'E}}{\text{arc P'P}}$, $\frac{\text{chord PP'}}{\text{arc PP'}}$ are ultimately each $= 1$; therefore,

$$\text{limit}\,\frac{v' - v}{z' - z} = 2\pi y, \text{ and } \frac{dv}{dz} = 2\pi y;$$

hence, $dv = 2\pi ydz = 2\pi y\sqrt{dx^2 + dy^2}$.

Now $2\pi y$ expresses the circumference of the section Pp; hence it appears that *the differential of the surface of revolution is equal to the differential of the arc of the generating curve multiplied by a section of the surface made by a plane perpendicular to the axis.*

165. Ex. 1. Let the solid be a sphere, of which the radius is a. Then, making AQ$=x$, PQ$=y$, the arc AP$=z$, the surface of the segment cut off by the plane P$p = v$; the equation of the curve being $y = \sqrt{2ax - x^2}$, we have

$$dy = \frac{adx - xdx}{\sqrt{2ax - x^2}},\; dz = \sqrt{dx^2 + dy^2} = \frac{adx}{\sqrt{2ax - x^2}} = \frac{adx}{y},$$

$$dv = 2\pi ydz = 2a\pi dx, \text{ and the surface } v = 2a\pi x;$$

here no constant is wanted, because we suppose that when $x = 0$, then $v = 0$.

Since $2a\pi$ is the circumference of a circle whose diameter is a, it follows that *the curve surface of a segment of a sphere is equal to a rectangle contained by a straight line equal to the circumference of the sphere and the height of the segment;* and hence it follows, that *the whole surface of the sphere is four times the area of one of its great circles.* These conclusions were found by Archimedes.

Ex. 2. To find the surface of a paraboloid. Put AQ $= x$, PQ $= y$, arc AP $= z$, curve surface generated by AP $= v$, the parameter $= 2a$. We found (article 160)

$dz = \frac{dy}{a}\sqrt{a^2 + y^2}$, hence,

$$dv = 2\pi ydz = \frac{2\pi}{a}ydy\sqrt{a^2 + y^2},$$

and, integrating, $v = \frac{2\pi}{a}\int ydy\sqrt{a^2 + y^2} = \frac{2\pi}{3a}(a^2 + y^2)^{\frac{3}{2}} + \text{C}.$

When $v = 0$, then $y = 0$; therefore, at the vertex we have

$$0 = \frac{2\pi a^3}{3a} + \text{C and C} = -\frac{2\pi a^3}{3a};$$

therefore, substituting for C, we have

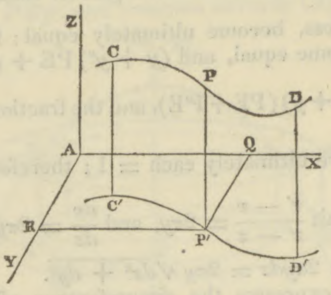
$$v = \frac{2\pi}{3a}\{(a^2 + y^2)^{\frac{3}{2}} - a^3\} = \frac{2}{3}\pi\{\sqrt{a(2x + a)^3} - a^2\}.$$

Rectification of Curves of Double Curvature.

166. Let CPD be a line of double curvature referred to three co-ordinate planes YAX, ZAX, ZAY. From every point in the curve let perpendiculars PP′, &c. be drawn to one of the planes, YAX; these will all be in the surface of a cylinder that meets the plane in a curve C′P′D, which will be the projection of the proposed curve. Again, from P′ draw P′Q, P′R perpendicular to AX, AY. Let AQ = P′R $= x$, AR = P′Q $= y$, P′P $= z$, the arc CP $= v$, its projection C′P′ $= v'$: Then $dv' = \sqrt{dx^2 + dy^2}$, (art 72). Suppose now the cylindric surface to be extended into a plane surface; the curve CPD will then be changed into a common plane curve, and its projection C′P′D′ into a straight line of the same length as before. We may now consider

Inverse Method.

Fig. 32.



v' and z as co-ordinates of the curve v, and then $dv = \sqrt{dv'^2 + dz^2}$; therefore, by substituting for dv'^2 its value $dx^2 + dy^2$, we find

$$dv = \sqrt{dx^2 + dy^2 + dz^2}.$$

This is a general formula for the rectification of any line of double curvature. The nature of the line will be expressed by two equations $f(x, y) = 0$, $\mathrm{F}(x, z) = 0$. From these we find $dy = \mathrm{P}dx$, $dz = \mathrm{Q}dx$, expressions in which P and Q are functions of x only. Thus we have $dv = dx\sqrt{1 + \mathrm{P}^2 + \mathrm{Q}^2} = dx\mathrm{R}$, R being a function of the single variable x. The integral $v = \int \mathrm{R}dx$ may now be found by the ordinary rules.

Integration of Differential Equations of two Variables.

167. Every differential equation of the first order which contains only the single powers of dx and dy, has the form $\mathrm{M}dx + \mathrm{N}dy = 0$, and it expresses the relation which subsists between the variable x, the function y, and its differential co-efficient $\frac{dy}{dx}$. The object of inquiry is to discover, if possible, the primitive equation $f(x, y) = 0$, which by differentiation may produce the proposed differential equation.

168. The method which first presented itself to analysts was to endeavour to separate the variables, so as to give it the form $\mathrm{X}dx + \mathrm{Y}dy = 0$, X being a function of x alone, and Y a function of y. When this can be done, the differentials $\mathrm{X}dx$, $\mathrm{Y}dy$ are separately integrable, and we have $\int \mathrm{X}dx + \int \mathrm{Y}dy = \mathrm{C}$ an arbitrary constant.

Let the equation be $mydx + nxdy = 0$; by dividing its terms by xy, it is changed to $\frac{mdx}{x} + \frac{ndy}{y} = 0$. The variables are now separated, and we have $\int \frac{mdx}{x} + \int \frac{ndy}{y} = m\,\mathrm{l}.\,x + n\,\mathrm{l}.\,y = \mathrm{C}$, or $\mathrm{l}.\,(x^m) + \mathrm{l}.\,(y^n) = \mathrm{C}$, or $\mathrm{l}.\,(x^m y^n) = \mathrm{C}$. We may suppose $\mathrm{C} = \mathrm{l}.\,c$, and then $x^m y^n = c$ is the primitive equation.

The variables may be separated when the differential equation has the form $\mathrm{X}dy + \mathrm{Y}dx = 0$, X being a function of x, and Y a function of y; for then $\frac{dx}{\mathrm{X}} + \frac{dy}{\mathrm{Y}} = 0$.

169. The variables may always be separated in *homogeneous equations*, the distinguishing property of which is, that the sum of the exponents of x and y is the same in each of its terms. For example, $ax^m y^n dx + bx^{m-1} y^{n+1} dy$ is a homogeneous equation; because the sum of the exponents of x and y is $m + n$ in each term. Let $\mathrm{M}dx + \mathrm{N}dy = 0$ be a homogeneous equation. Make $y = xz$, then M will take the form $\mathrm{Z}x^m$, and N the form $\mathrm{Z}_1 x^m$, Z and Z_1 being functions of z only; and since $dy = zdx + xdz$, the equation will be, after dividing by x^m, $\mathrm{Z}dx + \mathrm{Z}_1(xdz + zdx) = 0$, a result which may be put under the form

$$\frac{dx}{x} + \frac{\mathrm{Z}_1 dz}{\mathrm{Z} + z\mathrm{Z}_1} = 0;$$

from which we get

$$\int \frac{dx}{x} + \int \frac{\mathrm{Z}_1 dz}{\mathrm{Z} + z\mathrm{Z}_1} = \mathrm{C}.$$

170. Ex. 1. Let us apply this transformation to the equation $xdx + ydy = nydx$ or $(x - ny)\,dx + ydy = 0$, which, making $y = xz$, and therefore $dy = xdz + zdx$, becomes $x(1 - nz)\,dx + x^2zdz + xz^2dx = 0$, or $(1 - nz + z^2)\,dx + zdz = 0$, and $\int \frac{dx}{x} + \int \frac{zdz}{1 - nz + z^2} = \mathrm{C}$, or $\mathrm{l}.\,x + \int \frac{zdz}{1 - nz + z^2} = \mathrm{C}$. This integral may be simplified by observing that

$$\frac{zdz}{1 - nz + z^2} = \tfrac{1}{2}\,\frac{2zdz - ndz}{1 - nz + z^2} + \tfrac{1}{2}\,\frac{ndz}{1 - nz + z^2},$$

for it then becomes

$$\mathrm{l}.\,x + \tfrac{1}{2}\,\mathrm{l}.\,(1 - nz + z^2) + \tfrac{1}{2}\int \frac{ndz}{1 - nz + z^2} = \mathrm{C}.$$

The integral which yet remains to be found will depend on logarithms, if $\frac{1}{2}n > 1$; on arcs of circles, if $\frac{1}{2}n < 1$; and will be algebraical if $\frac{1}{2}n = 1$. In each case it may be had by the methods given for integrating rational fractions.

Ex. 2. Let it be proposed to integrate the equation

$$xdy - ydx = dx\sqrt{x^2 + x^2}.$$

By making $y = xz$, bringing all the terms to one side of the equation, and dividing by x, we shall have $dx\sqrt{1 + z^2} - xdz = 0$, and hence

$$\frac{dx}{x} - \frac{dz}{\sqrt{1 + z^2}} = 0;$$

and by the separate integration of each term,

$$\mathrm{l}.\,x - \mathrm{l}.\,(z + \sqrt{1 + z^2}) = \mathrm{l}.\,\mathrm{C}, \text{ or } \frac{x}{z + \sqrt{1 + z^2}} = \mathrm{C}.$$

and replacing z by its value x, there will result

$$\frac{x^2}{y + \sqrt{x^2 + y^2}} = \mathrm{C}, \text{ or } -y + \sqrt{x^2 + y^2} = \mathrm{C};$$

and hence again, by transposing y, and squaring, $x^2 = \mathrm{C}^2 + 2\mathrm{C}y$, which is the primitive equation.

The equation

$$(a + mx + ny)\,dx + (b + px + qy)\,dy = 0,$$

which is not homogeneous in its present form, may be transformed so as to become homogeneous. Assume $x = t + \alpha$, $y = u + \beta$, then $dx = dt$, $dy = du$, and the proposed equation becomes
$(a + m\alpha + n\beta + mt + nu)dt + (b + p\alpha + q\beta + pt + qu)du = 0.$
To make the constant terms disappear, we assume $a + m\alpha + n\beta = 0$, $b + p\alpha + q\beta = 0$, equations which determine α and β, and then there remains the different equation

$$(mt + nu)\,dt + (pt + qu)\,du = 0,$$

which is homogeneous in respect of the new variables t and u. This transformation gives no result when $mq - np = 0$, a case in which α and β become infinite; but then $q = \frac{np}{m}$; and consequently $m(px + qy) = p(mx + ny)$. The proposed equation being changed to

$$adx + bdy + (mx + ny)\left(dx + \frac{p}{m}dy\right) = 0,$$

we now make $mx + ny = z$, so that $dy = \frac{dz - mdx}{n}$; by substitution and proper reduction our equation now becomes

$$dx + \frac{(bm + pz)\,dz}{amn - bm^2 + m\,(n - p)\,z} = 0.$$

The integral of this equation will contain logarithms, except in the case where $n = p$, when it will be

$$x + \frac{2bmz + pz^2}{2m\,(an - bm)} = \mathrm{C}.$$

171. The separation of the variables is easily effected in the equation $dy + \mathrm{P}ydx = \mathrm{Q}dx$, where P and Q denote any functions whatever of x. Substituting $\mathrm{X}z$ and $zd\mathrm{X} + \mathrm{X}dz$ instead of y and dy, it becomes

$$zd\mathrm{X} + \mathrm{X}dz + \mathrm{PX}zdx = \mathrm{Q}dx.$$

Here X denotes an indeterminate function of x, to which we may give such a form as shall conduce to the separation of the variables. For this purpose we make $\mathrm{X}dz + \mathrm{PX}zdx = 0$, which requires that $zd\mathrm{X} = \mathrm{Q}dx$. If we divide the first equation by X, it becomes $dz + \mathrm{P}zdx = 0$, from which we deduce $\frac{dz}{z} + \mathrm{P}dx = 0$, and $\mathrm{l}.\,z + \int \mathrm{P}x = 0$; and passing from logarithms to numbers, $z = e^{-\int \mathrm{P}dx}$ (here e is the base of Napier's logarithms), we neglect the arbitrary constant in the mean time, as it will be added at the end of the operation. Afterwards, deducing the value of $d\mathrm{X}$ from the second equation, and substituting it in the first, we shall have

$$d\mathrm{X} = e^{\int \mathrm{P}dx}\,\mathrm{Q}dx,\ \mathrm{X} = \int e^{\int \mathrm{P}dx}\,\mathrm{Q}dx + \mathrm{C},$$

and consequently,

$$y = e^{-\int \mathrm{P}dx}\{\int e^{\int \mathrm{P}x}\,\mathrm{Q}dx + \mathrm{C}\}$$

Ex. Let the equation be $dy + ydx = ax^3\,dx$: then $\mathrm{P} = 1, \mathrm{Q} = ax^3, \int \mathrm{P}dx = x, e^{\int \mathrm{P}dx} = e^x, e^{-\int \mathrm{P}dx} = e^{-x}$; $\int e^{\int \mathrm{P}dx}\,\mathrm{Q}dx = \int ae^x\,x^3dx = ae^x\,(x^3 - 3x^2 + 6x - 6)$; therefore $y = e^{-x}\,\{ae^x(x^3 - 3x^2 + 6x - 6) + \mathrm{C}\}$

$$= \mathrm{C}e^{-x} + a\,(x^3 - 3x^2 + 6x - 6).$$

172. The early writers on the integral calculus classed differential equations by the number of their terms. In equations which had but two terms, and whose form is consequently $\beta u^g z^h dz = \alpha u^e z^f du$, the variables are separated immediately, since we thence deduce $\beta z^{h-f} dz = \alpha u^{e-g} du$. This however is not the case with equations of three terms, which are expressed by the formula

$$\gamma u^i z^k\,dz + \beta u^g z^h\,du = \alpha u^e z^f du.$$

This may be simplified by dividing the terms by $\gamma u^i z^f$, it then becomes

$$z^{k-f} dz + \frac{\beta}{\gamma} u^{g-i} z^{h-f} du = \frac{\alpha}{\gamma} u^{e-i}\,du.$$

Suppose now $z^{k-f} dz = \frac{dy}{k - f + 1}$, $u^{g-i} du = \frac{dx}{g - i + 1}$; then we have $z^{k-f+1} = y$, $u^{g-i+1} = x$, and

$$dy + \frac{(k - f + 1)\beta}{(g - i + 1)\gamma}\,y^{\frac{k-f}{k-f+1}}\,dx = \frac{(k - f + 1)\alpha}{(g - i + 1)\beta}\,x^{\frac{e-g}{g-i+1}}\,dx.$$

To abridge, let us put

$$b = \frac{(k - f + 1)\,\beta}{(g - i + 1)\,\gamma},\quad a = \frac{(k - f + 1)\,\alpha}{(g - i + 1)\,\gamma},$$

$$n = \frac{h - f}{k - f + 1},\quad m = \frac{e - g}{g - i + 1};$$

and the equation will become

$$dy + by^n dx = ax^m dx.$$

When $n = 1$, the equation belongs to the class treated of in last article. When $n = 2$, the equation is

$$dy + by^2 dx = ax^m dx,$$

which was first considered by an Italian geometer, *Riccati*, whose name it bears. When $m = 0$, the variables are separable, and we have

$$dx = \frac{dy}{a - by^2}.$$

Proceeding from this case, analysts have succeeded in separating the variables when m is any number of the form $\frac{-4i}{2i \pm 1}$, i being supposed an integer number. Riccati's equation was first considered by James Bernoulli, who gave an approximate solution of it. (Jac. Bernoulli *Opera*, p. 1053.) The general problem, however, remains yet unresolved.

173. When a differential equation is the immediate result of the differentiation of a known function, then that function, put equal to C a constant, will be the integral required. The differential equation $xdy + ydx = 0$ is of this class; it is the differential of the product xy, therefore the primitive equation is $xy = \mathrm{C}$. A differential equation may, however, not be the immediate result of the differentiation of a function of x and y; it may be formed by the elimination of some constant quantity contained in the function and also in its differential (art. 54); or it may be the result after the differential of the primitive has been divided by some factor common to all its terms. Thus, if the primitive be $y = cx$, or $y - cx = 0$, the differential equation is $dy - cdx = 0$. If however we eliminate c by the usual algebraic process, we find $xdy - ydx = 0$, an expression which is not the immediate result of any differentiation. The same result will be obtained if the primitive $x = cy$ be put under the form $\frac{x}{y} = c$; for then, by differentiating, $\frac{ydx - xdy}{y^2} = 0$, and, rejecting the factor $\frac{1}{y^2}$, $ydx - xdy = 0$. This expression is not an exact differential; however, it becomes so by restoring the factor $\frac{1}{y^2}$, and then it is the differential of $\frac{x}{y}$.

174. In general let $u = f(x, y)$ be the primitive equation, the differential being $du = \mathrm{M}dx + \mathrm{N}dy$, where M denotes $\frac{du}{dx}$, that is, the differential co-efficient found on the supposition that x is variable and y constant, and N denotes $\frac{du}{dy}$, the co-efficient taken on the reverse hypothesis of y being variable and x constant; now we have found that $\frac{d^2u}{dxdy} = \frac{d^2u}{dydx}$ (art. 89); therefore, if $\mathrm{M}dx + \mathrm{N}dy$ be the differential of $u = f(x, y)$, then

$$\frac{d\mathrm{M}}{dy} = \frac{d\mathrm{N}}{dx} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Hence, *If* Mdx + Ndy *is an exact differential, the condition expressed by formula* (1) *will always be satisfied. And, conversely, if* M *and* N *are such functions of* x *and* y *that* $\frac{\mathrm{dM}}{\mathrm{dy}} = \frac{\mathrm{dN}}{\mathrm{dx}}$, *then* Mdx + Ndy *shall be an exact differential, and in every case its integral may be found.* This is called the *Condition of Integrability.*

To prove the second part of the proposition, let us suppose that the integral of Mdx is taken on the supposition that in the function M, x is variable and y constant; and let the integral be $P+Y$, where Y is any function of y, which comes in the place of the indeterminate constant that enters into every integral, and P is a known function of x and y, which results from $\int Mdx$ relatively to x only, so that $M=\frac{dP}{dx}$.

The complete differential of $P+Y$ is (art. 91) $\frac{dP}{dx}dx+\frac{dP}{dy}dy+dY$, or $Mdx+\frac{dP}{dy}dy+dY$. By comparing this with the differential $Mdx+Ndy$, it appears that if such a value be given to Y that $Ndy=\frac{dP}{dy}dy+dY$, or that

$$dY=\left(N-\frac{dP}{dy}\right)dy\ldots\ldots\ldots\ldots(2)$$

then the integral of $Mdx+Ndy$ will be $P+Y$. Now, by differentiating $M=\frac{dP}{dx}$ in respect of y, we have $\frac{dM}{dy}=\frac{d^2P}{dydx}$, but by hypothesis $\frac{dM}{dy}=\frac{dN}{dx}$, and $\frac{d^2P}{dydx}=\frac{d^2P}{dxdy}$ (art. 89), therefore $\frac{dN}{dx}=\frac{d^2P}{dxdy}$, and $\frac{dN}{dx}-\frac{d^2P}{dxdy}=0$, that is, $d\left(N-\frac{dP}{dy}\right)=0$, the differential being taken supposing x only to be variable; therefore $N-\frac{dP}{dy}$ is constant in respect of x, and is a function of y only; hence the possibility of finding $Y=\int\left(N-\frac{dP}{dy}\right)dy$ is proved, and we have the integral of $Mdx+Ndy$ expressed by $P+\int\left(N-\frac{dP}{dy}\right)dy$, and here $P=\int Mdx$, the integral being taken on the supposition that y is constant.

We may begin with finding the integral of Ndy, supposing x to be constant, proceeding in all respects as has been explained. In general we ought to begin with the term which brings out the integral with least calculation.

Ex. 1. It is proposed to find whether the differential $\frac{ydx-xdy}{x^2+y^2}$ satisfies the condition of integrability, and, if it does, to integrate it.

We put the differential under the form

$$du=\frac{y}{x^2+y^2}dx-\frac{x}{x^2+y^2}dy,$$

therefore $M=\frac{y}{x^2+y^2}$, $\quad N=-\frac{x}{x^2+y^2}$,

$$\frac{dM}{dy}=\frac{x^2-y^2}{(x^2+y^2)^2},\quad \frac{dN}{dx}=\frac{x^2-y^2}{(x^2+y^2)^2}.$$

The condition of integrability is in this case satisfied, and therefore $\frac{ydx-xdy}{x^2+y^2}$ is an exact differential.

To determine the integral, we have

$$P=\int Mdx=\int\frac{ydx}{x^2+y^2}=\int\frac{\frac{dx}{y}}{1+\frac{x^2}{y^2}}=\tan^{-1}\frac{x}{y},$$

whence $u=\tan^{-1}\frac{x}{y}+Y$.

Differentiating, and considering the whole as variable,

$$du=\frac{ydx-xdy}{x^2+y^2}+dY.$$

This, compared with the proposed differential, shows that $dY=0$, and $Y=C$ a constant.

Ex. 2. To find the integral of the differential

$$du=(2y^2x+3y^3)\,dx+(2x^2y+9xy^2+8y^3)\,dy.$$

In this example, $M=2y^2x+3y^3$, $N=2x^2y+9xy^2+8y^3$,

$$\frac{dM}{dy}=4yx+9y^2=\frac{dN}{dx};$$

the proposed function is therefore a complete differential.

Integrating in respect of x, we find

$$\int Mdx=y^2x^2+3y^3x+Y,$$

and $u=y^2x^2+3y^3x+Y$.

Differentiating this expression in respect of y,

$$\frac{du}{dy}=2x^2y+9xy^2+\frac{dY}{dy},$$

but we had $\frac{du}{dy}=2x^2y+9xy^2+8y^3$;

therefore, $\frac{dY}{dy}=8y^3$, and $Y=\int 8y^3dy=2y^4+C$,

and consequently the integral is

$$u=y^2x^2+3y^3x+2y^4+C.$$

175. If in the equation $Mdx+Ndy=0$, the condition of integrability, viz. $\frac{dM}{dy}=\frac{dN}{dx}$, is not satisfied, we may next inquire whether some factor, a function of x and y, can be found by which the expression $Mdx+Ndy$ can be rendered a complete differential.

Let the equation be put under the form $\frac{dy}{dx}+K=0$, where $K=\frac{M}{N}$. This equation is the result of the elimination of a constant quantity c between a primitive equation, which may be represented by $f(x,y,c)=0$ and its immediate differential. Or else c may be eliminated directly by bringing the primitive equation to the form $F(x,y)=c$, which will lead to the same result (art 53). Put u for $F(x,y)$, also Pdx for the differential of u taken relatively to x, and Qdy for its differential relatively to y, so that $du=Pdx+Qdy$, and $\frac{du}{dx}=P+Q\frac{dy}{dx}=0$, therefore $P+Q\frac{dy}{dx}=0$. Since this equation does not contain C, it ought to be identical with the equation $\frac{dy}{dx}+K=0$;

therefore $\frac{dy}{dx}+K=\frac{dy}{dx}+\frac{P}{Q}=\frac{Pdx+Qdy}{Qdx}$, that is, $\frac{dy}{dx}+K=\frac{du}{Qdx}$, and hence

$$Q(dy+Kdx)=du.$$

Now the second side of the equation is a complete integral; hence it appears that *there is always a factor* Q, *by which, if the differential equation* $dy+Kdx=0$ *be multiplied, the result will be a complete integral.*

Let both sides of the equation be multiplied by U, any function of U, and we have

$$UQ(dy+Kdx)=Udu.$$

Now Udu is still a complete differential, and as the factor UQ may have an infinite variety of forms, it follows that *there are an infinite number of factors, such that if a differential equation be multiplied by any one of them, it will be a complete differential.*

Inverse Method.

Since it appears that when the equation $\text{M}dx+\text{N}dy=0$ does not satisfy the condition of integrability, it is because differentiation and subsequent elimination of the arbitrary constant have caused a factor to disappear, which, if it were known and restored, would render the expression a complete differential, the discovery of that factor is a most important problem in the calculus. Its solution, however, transcends the present powers of analysis, although it can be resolved in particular cases. When the functions M and N are homogeneous, the factor can be found; but that case can always be integrated as has been explained. When the variables can be separated, a multiplier can be found, but then it is not wanted. It can also be found when the equation has the form $dy+\text{P}ydx=\text{Q}dx$; but this also can be integrated by other means.

Euler, who has entered deeply into this subject, has reversed the problem; and, in his *Calculus Integralis*, supposing the integrating factor given, has investigated the nature of the functions which must enter into a differential equation of a given form, in order that it may be integrable. These investigations, however, frequently lead to differential equations, which cannot be integrated by any known method; and the cases in which they are successful are of no great importance or extent.

176. Let M be any function of x and y, and let $u=\int\text{M}dx$, the integral being taken on the supposition that x is variable and y constant: it is sometimes required that the differential co-efficient $\frac{du}{dy}$ be found; or, in other words, that the differential of $\int\text{M}dx$ relatively to y be found without having actually integrated the expression relatively to x. Because $u=\int\text{M}dx$, therefore $\frac{du}{dx}=\text{M}$, and $\frac{d^2u}{dxdy}=\frac{d\text{M}}{dy}$; but $\frac{d^2u}{dxdy}=\frac{d^2u}{dydx}$ (art. 89), therefore $\frac{d^2u}{dydx}=\frac{d\text{M}}{dy}$, and $\frac{d^2u}{dy}=\frac{d\text{M}}{dy}dx$, and integrating relatively to x, $\frac{du}{dy}=\int\frac{d\text{M}}{dy}dx$.

Ex. Let $u=\int\frac{ydx}{\sqrt{y^2-x^2}}$, here $\text{M}=\frac{y}{\sqrt{y^2-x^2}}$, and $\frac{d\text{M}}{dy}=\frac{-x^2}{(y^2-x^2)^{\frac{3}{2}}}$, and $\frac{du}{dx}=\int\frac{-x^2dx}{(y^2-x^2)^{\frac{3}{2}}}$.

The theorem investigated in this article was found by Leibnitz, and was reckoned an important discovery in the calculus. (See Bossut, *Traité du Calcul Diff.* &c. vol. ii. p. 58.)

177. The elimination of a constant contained in a primitive equation may introduce the second or higher powers of the differentials into the resulting differential equation (art. 53): in such cases we must find the values of $\frac{dy}{dx}$ by the resolution of an equation.

For example, if $dy^2-a^2dx^2=0$, or $\frac{dy^2}{dx^2}=a^2$, we have $\frac{dy}{dx}=\pm a$ and $dy+adx=0$, also $dy-adx=0$; therefore $y+ax+c=0$ and $y-ax+c'=0$ are two primitive equations, from each of which the differential equation may be derived; also from their product $(y+ax+c)(y-ax+c')=0$.

178. When the equation contains only one of the variables, x for example, we deduce from it $\frac{dy}{dx}=\text{X}$, and $y=\int\text{X}dx$; but if the equation be more easily resolvable with respect to x than with respect to the co-efficient $\frac{dy}{dx}$, which we will represent by p, and if we have also $x=\text{P}$, a function of p, and thence $dx=d\text{P}$; then, since $dy=pdx$, therefore $dy=pd\text{P}$, and $y=p\text{P}-\int\text{P}dp$. The relation between x and y is now to be found by eliminating p by means of the equations

$$x=\text{P},\quad y=\text{P}p-\int\text{P}dp.$$

Let us take as an example $xdx+ady=b\sqrt{dx^2+dy^2}$, or $x+ap=b\sqrt{1+p^2}$, by writing p in the place of $\frac{dy}{dx}$. This last equation gives immediately $x=-ap+b\sqrt{1+p^2}$, and consequently

$$y=bp\sqrt{1+p^2}-\tfrac{1}{2}ap^2-b\int dp\sqrt{1+p^2}.$$

179. When the primitive equation cannot be deduced from the differential equation by any of the known artifices of analysis, then, as a last resource, recourse must be had to approximation by infinite series.

Ex. Let the differential equation be $dy+ydx=mx^ndx$, and suppose it to be known that when $x=a$, then $y=b$: we now make $x=a+t$, $y=b+u$, the equation by this transformation becomes $du+(b+u)dt=m(a+t)^ndt$. We now assume that

$$u=\text{A}t^\alpha+\text{B}t^{\alpha+1}+\text{C}t^{\alpha+2}+\&\text{c.}$$

and hence, putting instead of u and du their values, and bringing the terms to one side, we have

$$\left.\begin{array}{l}\alpha\text{A}t^{\alpha-1}+(\alpha+1)\text{B}t^\alpha+(\alpha+2)\text{C}t^{\alpha+1}+\&\text{c.}\\ +b\quad+\quad\text{A}t^\alpha\quad+\quad\text{B}t^{\alpha+1}+\&\text{c.}\\ -ma^n-m\frac{n}{1}a^{n-1}t-m\frac{n(n-1)}{1.2}a^{n-2}t^2-\&\text{c.}\end{array}\right\}=0.$$

In this equation we must suppose $\alpha-1=0$, and we shall then find

$$\text{A}=ma^{n-1}-b,\ \text{B}=\frac{mna^{n-1}-ma^n+b}{1.2},$$

$$\text{C}'=\frac{mn(n-1)a^{n-2}-mna^{n-1}+ma^n-b}{1.2.3},\ \&\text{c.}$$

These values being substituted in the series, we have u expressed by t and known quantities; we may then put $x-a$ for t, and $y-b$ for u, and the result will express the relation between x and y.

In the series assumed for the value of u, the exponents of t form an arithmetical progression, of which the common difference is 1. In many cases, however, the common difference will be a fraction, as in this example, $(dx+dy)\,y=dx$. Here we assume

$$y=\text{A}x^a+\text{B}x^b+\text{C}x^c+\&\text{c.}$$

By proceeding as before, there is obtained

$$\left.\begin{array}{l}\text{A}^2ax^{2a-1}+\text{AB}ax^{a+b-1}+\text{AC}ax^{a+c-1}+\&\text{c.}\\ \qquad\qquad+\text{AB}bx^{a+b-1}+\text{B}^2bx^{2b-1}+\&\text{c.}\\ \qquad\qquad\qquad\qquad+\text{AC}cx^{a+c-1}+\&\text{c.}\\ \qquad\qquad\qquad\qquad\qquad\qquad+\&\text{c.}\\ -1\quad+\text{A}x^a\quad+\text{B}x^b\end{array}\right\}=0.$$

Hence $2a-1=0$, $a+b-1=a$, $a+c-1=b$, &c.;

therefore $a=\frac{1}{2}$, $b=1$, $c=\frac{3}{2}$, &c.

Again, $\text{A}^2a=1$, $\text{AB}(a+b)+\text{A}=0$, &c.

Hence $\text{A}=\sqrt{2}$, $\text{B}=-\frac{2}{3}$, $\text{C}=\frac{1}{18}\sqrt{2}$, &c.

and $y=x^{\frac{1}{2}}\sqrt{2}-\frac{2}{3}x^{\frac{2}{2}}+\frac{1}{18}x^{\frac{3}{2}}\sqrt{2}-\&\text{c.}$

On the integration of differential equations by series, consult Euler, *Instit. Cal. Integ.* vol. i. sect. 2; Lacroix, *du Calcul Diff.* part ii. chap. 6.

Differential Equations of the Second and Higher Orders.

180. The difficulty of the integrations becomes so much the greater the higher the order of the differential co-efficients which they involve, and we only succeed in effecting it in a very small number of very limited equations.

Let the expression

$$f(x,\ y,\ c,\ c') = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

represent any primitive equation composed of the variables x, y, and two constant quantities c, c', besides any other constants. By differentiation (as explained art. 48–54), there is formed its differential equation of the first order, which will contain $\frac{dy}{dx}$. Let this differential co-efficient be represented by p, and let $q = \frac{dp}{dx} = \frac{d^2y}{dx}$. The differential of the first order will contain x, y, p, c, c', and may be represented by

$$f'(x,\ y,\ p,\ c,\ c') = 0 \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

By differentiating this equation we obtain another which contains also $\frac{d^2y}{dx^2} = q$, and may be expressed by

$$f''(x, y, p, q, c, c') = 0 \ldots\ldots\ldots\ldots\ldots (3)$$

Since these three equations must hold true at once, we may eliminate the constants c, c', and the result will be a single equation,

$$\mathrm{F}(x, y, p, q) = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

in which c, c' are not found. This will be the differential equation of the second order, deducible from the primitive (1), and which is independent of the constants c, c'.

We may arrive at the very same equation (4) in two other ways. We may give the primitive (1) these forms:

$$\varphi(x, y, c) = c', \quad \psi(x, y, c') = c,$$

from which, by differentiation, two results will be obtained, one entirely free from c', and the other from c: these again may have the forms

$$\varphi'(x, y, p) = c, \quad \psi'(x, y, p) = c'.$$

By taking now the differentials of these equations, we shall obtain the very same equation from each, which will be identical with equation (4).

For example, let the primitive equation be

$$x^2 - 2ax + 2by = 0,$$

in which a and b represent the constants c, c'; by differentiation, we find

$$x - a + b\frac{dy}{dx} = 0, \quad 1 + b\frac{d^2y}{dx^2} = 0.$$

After eliminating a and b by the three equations, we have this differential equation,

$$2y - 2x\frac{dy}{dx} + x^2\frac{d^2y}{dx^2} = 0.$$

We may otherwise put the primitive equation under these forms:

$$\frac{x^2 + 2by}{x} = 2a, \quad \frac{x^2 - 2ax}{y} = -2b.$$

Taking now the differentials, and arranging the results so that the constants may stand alone, and putting p instead of $\frac{dy}{dx}$, we have

$$\frac{x^2}{y - xp} = 2b, \quad \frac{2xy - x^2p}{y - xp} = 2a.$$

By differentiating either of these, the constants disappear, and in each case the result is the same, viz.

$$2y - 2x\frac{dy}{dx} + x^2\frac{d^2y}{dx^2} = 0.$$

181. Since two of the constants in a primitive equation may not be found in the differential equation of the second order derived from it, so, reversely, in returning from a differential equation of the second order to its absolute primitive, *the latter cannot be complete unless it contain two arbitrary constants, which are not in the former;* and as the same differential equation of the second order may be obtained from two distinct differential equations of the first order, it follows that *every differential equation of the second order has two distinct differential equations of the first order, each having its own arbitrary constant; and these again have one and the same absolute primitive equation.* The properties of differential equations of the third and higher orders are perfectly analogous to these.

182. The most simple differential equation of the second order is $\frac{d^2y}{dx^2} = \mathrm{X}$, a function of x; then $\frac{dy}{dx} = \int \mathrm{X}dx$. Let P be the variable part of the integral $\int \mathrm{X}dx$, and c the constant, so that $\frac{dy}{dx} = \mathrm{P} + c$; hence again $dy = \mathrm{P}dx + cdx$, and by a second integration, $y = \int \mathrm{P}dx + cx + c'$. Since $\int \mathrm{P}dx = \mathrm{P}x - \int x d\mathrm{P} = x\int \mathrm{X}dx - \int x\mathrm{X}dx$, therefore,

$$y = x\int \mathrm{X}dx - \int x\mathrm{X}dx + cx + c'.$$

The primitive of the differential equation $d^3y - \mathrm{X}dx^3 = 0$ may be found in the same way. We first put it under the form $\frac{d^3y}{dx^2} = \mathrm{X}dx$; then we have by a first integration $\frac{d^2y}{dx^2} = \int \mathrm{X}dx = \mathrm{P} + c$; and hence $\frac{d^2y}{dx} = \mathrm{P}dx + cdx$; by a second integration, $\frac{dy}{dx} = \int \mathrm{P}dx + cx + c' = \mathrm{P}' + cx + c$; here $\mathrm{P}' = \int \mathrm{P}dx$. We have now $dy = \mathrm{P}'dx + cxdx + c'dx$; and lastly, $y = \int \mathrm{P}'dx + \frac{1}{2}cx^2 + c'x + c''$. The primitive thus containing three arbitrary constants: a like differential equation of the fourth order would contain four, and so on.

183. When a differential equation of the second order involves $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$, and constants; if we put $\frac{dy}{dx} = p$, then, regarding dx as constant, $\frac{d^2y}{dx^2} = \frac{dp}{dx}$; the equation will now involve p, dp, dx and constants; and it will be of the first order, in respect of p and x. We may thence find $dx = \mathrm{P}dp$, P being here put for some function of p; and since $dy = pdx = \mathrm{P}pdp$, we have

$$x = \int \mathrm{P}dp, \quad y = \int \mathrm{P}pdp.$$

These integrals being found, and a constant added to each, by eliminating p, we find an equation expressing the relation between x and y.

Ex. To integrate the equation $\frac{(dx^2 + dy^2)^{\frac{3}{2}}}{dxd^2y} = a$. By putting pdx for dy, and $dpdx$ for d^2y, the equation is changed to $\frac{(1+p^2)^{\frac{3}{2}}dx}{dp} = a$, from which we deduce

$$dx = \frac{adp}{(1 + p^2)^{\frac{3}{2}}}, \quad dy = pdx = \frac{apdp}{(1 + p^2)^{\frac{3}{2}}}.$$

The integration gives

$$x = c + \frac{ap}{\sqrt{1 + p^2}}, \quad y = c' - \frac{a}{\sqrt{1 + p^2}}.$$

Hence $(c - x)^2 + (y - c')^2 = a^2$.

The proposed differential equation is nothing more than the general expression of the radius of curvature (art. 78) made equal to a constant quantity a. We have resolved the geometrical problem, to find a curve whose radius of curvature is a constant, and found it to be a circle, as was obvious.

184. We may remark, that the equation $x = C + \int \frac{dp}{P}$, and $dy = C' + \int \frac{pdp}{P}$, severally satisfy the differential equation $\frac{dp}{dx} = P$; and that, by supposing their second members integrated, they will be only of the first order. This agrees with what was observed, art. 181, viz. that there are two equations of the first order which satisfy a differential equation of the second order.

185. Let us now consider differentials of the form $\frac{d^2y}{dx^2} = Y$, Y representing any function of y. If we make $dy = pdx$, we thence deduce $dx = \frac{dy}{p}$, which gives $\frac{d^2y}{dx^2} = \frac{dp}{dx} = \frac{pdp}{dy}$. Substituting this in the proposed equation, there results from it $pdp = Ydy$; by integrating, we find $p^2 = 2\int Ydy$, C, and hence

$$p = \frac{dy}{dx} = \sqrt{C + 2\int Ydy}, \text{ and } x = \int \frac{dy}{\sqrt{C + 2\int Y dy}} + C'.$$

It is proper to observe that the above integration may be effected by multiplying the proposed equation by dy, for thence we find $\frac{dy}{dx} \cdot \frac{d^2y}{dx} = Ydy$; and since $\frac{d^2y}{dx} = d\frac{dy}{dx}$, we have $\frac{1}{2}\frac{dy^2}{dx^2} = \int Ydy + C$, or $\frac{dy}{dx} = \sqrt{2\,C + 2\int Ydy}$.

Ex. Let the equation be $d^2y\sqrt{ay} = dx^2$; we shall have

$$\frac{d^2y}{dx^2} = \frac{1}{\sqrt{ay}}, \quad \frac{dy}{dx} \cdot \frac{d^2y}{dx} = \frac{dy}{\sqrt{ay}},$$

and, by integrating, $\frac{1}{2}\frac{dy^2}{dx^2} = \frac{2}{a}\sqrt{ay} + C$; changing C into $\frac{2c}{\sqrt{a}}$, we shall deduce from thence

$$\frac{dy^2}{dx^2} = \frac{4}{\sqrt{a}}(\sqrt{y} + c), \quad \frac{2dx}{\sqrt[4]{a}} = \frac{dy}{\sqrt{c + \sqrt{y}}}.$$

Now, making $c + \sqrt{y} = z$, there will result

$$\frac{dx}{\sqrt[4]{a}} = \frac{(z - c)}{\sqrt{z}}\, dz = (z^{\frac{1}{2}} - cz^{-\frac{1}{2}})dz;$$

and finally,

$$\frac{x}{\sqrt[4]{a}} = \tfrac{2}{3} z^{\frac{3}{2}} - 2cz^{\frac{1}{2}} + c' = \tfrac{2}{3}(\sqrt{y} - 2c)\sqrt{c + \sqrt{y}}. + c'.$$

186. We have seen in the differential calculus, art. 93, that beyond the first order the form of the differential equations would be changed, according as x or y, or even a function of these quantities, was assumed as the *independent variable*; which comes to the same thing as assuming that dx, or dy, or a given function of these variables, was constant. It is therefore necessary, in integrating equations which exceed the first degree, to know upon which of these hypotheses it has been calculated. The preceding examples all correspond to the case of y being a function of x, and consequently of dx being constant; but it will be easy to discover, among relations deduced relatively to other hypotheses, to which of them they may be referred.

It is immediately evident that, if we represent by Q any function whatever of $\frac{dx}{dy}$, every equation of the form $\frac{d^2x}{dy^2} = Q$, and in which dy is constant, may be treated in the same way as that in art. 183, by making $\frac{dx}{dy} = q$, and $\frac{d^2x}{dy^2} = \frac{dq}{dy}$. It may also be reduced immediately to the form $\frac{d^2y}{dx^2} = P$, by passing by the formula of art. 93, to the hypothesis of dx being constant, which will be effected by the substitution of $\frac{-dxd^2y}{dy^3}$ in place of $\frac{d^2x}{dy}$.

If the proposed equation had been taken on the supposition of $\sqrt{dx^2 + dy^2}$ being constant, and if it involved only dx, dy, d^2y, or dy, dx, dx^2, it might still be treated in the same manner as that of art. 183, after transforming it into one in which dx was constant.

187. When the equation contains $\frac{d^2y}{dx^2}$, $\frac{dy}{dx}$ and the variable x, it may, as before, be transformed into a differential equation of the first order, by substituting pdx for dy, and $dpdx$ for d^2y; then, if the primitive of that differential equation, and thence the value of p in terms of x, can be found, we may have the value of y from the formula $y = \int pdx$; or else, if we have the value of x in terms of p, then, because $\int pdx = px - \int xdp$, we shall have $y = px - \int xdp$.

Ex. Let the equation be

$$-\frac{(dx^2 + d^2y)^{\frac{3}{2}}}{dxd^2y} = X \text{ or } -\frac{(1+p^2)^{\frac{3}{2}}dx}{dp} = X,$$

where x denotes a given function of x; then

$$\frac{dx}{X} = \frac{-dp}{(1 + p^2)^{\frac{3}{2}}} \text{ and } \int \frac{dx}{X} + C = \frac{-p}{\sqrt{1 + p^2}}.$$

Let V represent $\int \frac{dx}{X} + C$, then $p = \frac{V}{\sqrt{1 - V^2}}$, and $y = \int pdx + C' = \int \frac{Vdx}{\sqrt{1 - V^2}} + C'$; y is now expressed by means of x only. This is the analytical solution of the geometrical problem to find the nature of a curve whose radius of curvature shall be a given function of x, the absciss.

If we suppose $X = \frac{a^2}{2x}$, then $\frac{-p}{\sqrt{1 + p^2}} = \int \frac{2xdx}{a^2} = \frac{x^2}{a} + C$,

$$p^2 = \frac{dy^2}{dx^2} = \frac{x^2 + c}{a^4 - (x^2 + c^2)^2} \text{ and } y = \int \frac{(x^2 + c)dx}{\sqrt{\{a^4 - (x^2 + c)^2\}}};$$

here c is put generally for an indeterminate constant. This is the equation of the elastic curve.

188. If the proposed differential equation is composed of $\frac{d^2y}{dx^2}$, $\frac{dy}{dx}$, and y, we may, as before, put $p = \frac{dy}{dx}$, from which we get $\frac{d^2y}{dx^2} = \frac{dp}{dx} = \frac{pdp}{dy}$; the equation will now involve dp, dy, p and y only. When the primitive equation can be found, and thence the value of p in terms of y, we may find x by the formula $x = \int \frac{dy}{p}$; but when y is expressed by p, we may then employ the formula $x = \frac{y}{p} + \int \frac{ydp}{p^2}$.

189. Differentials of the second order, which have this form,

$$\frac{d^2y}{dx^2} + P\frac{dy}{dx} + Qy = R,$$

in which P, Q, R are any functions of x, are called *linear*, also equations of the *first degree*, because y is only of one dimension. It will easily be understood that the difficulty of finding the primitive equation will be greater than in the like equation of the first order; and, indeed, except in particular cases, there is no known method of reducing the integration to the finding of the differential of a single variable; that is, to the quadrature of a curve. If $\mathrm{R} = 0$, in which case the equation is

$$\frac{d^2y}{dx^2} + \mathrm{P}\frac{dy}{dx} + \mathrm{Q}y = 0,$$

it may be reduced to a differential equation of the first degree, by a very simple transformation. Let e, as usual, denote the base of Napier's logarithms; assume $y = e^{\int udx}$, then, regarding x as constant, we have

$$dy = udxe^{\int udx},\ d^2y = e^{\int udx}\ (dudx + u^2dx^2):$$

the value of dy and d^2y being substituted in the equation, and the common factors rejected, it becomes

$$du + (u^2 + \mathrm{P}u + \mathrm{Q})\,dx = 0.$$

When P and Q are constants, which may be represented by A and B, the equation becomes

$$du + (u^2 + \mathrm{A}u + \mathrm{B})\,dx = 0;$$

in which the variables are separated, if we give it the form

$$\frac{du}{u^2 + \mathrm{A}u + \mathrm{B}} + dx = 0.$$

As it is merely necessary to satisfy this equation, we may make $u = m$, m being any constant; then $du = 0$, and $m^2 + \mathrm{A}m + \mathrm{B} = 0$. This last equation gives, in general, two values of m; if we represent them by a and b, we shall have two values of $\int udx$; viz. $ax + c$ and $bx + c'$, and hence we have two values of y, viz.

$$y = e^{ax+c},\quad y = ^{bx+c'};$$

or, putting C for e^c, and C′ for $e^{c'}$,

$$y = \mathrm{C}e^{ax},\quad y = \mathrm{C}'e^{bx}.$$

These, however, are only *particular* values of the function y, because each contains only a single arbitrary constant; but by adding them, we get

$$y = \mathrm{C}e^{ax} + \mathrm{C}'e^{bx}$$

as the complete primitive equation.

To prove this, by differentiating, we get

$$\frac{dy}{dx} = a\mathrm{C}e^{ax} + b\mathrm{C}'e^{bx},\quad \frac{d^2y}{dx^2} = a^2\,\mathrm{C}e^{ax} + b^2\,\mathrm{C}'e^{bx}.$$

From these and the above primitive equation, we have, after eliminating C and C′,

$$\frac{d^2y}{dx^2} + (a + b)\frac{dy}{dx} - aby = 0.$$

This will agree with the proposed equation, if we give a and b such values that $a + b = \mathrm{P}$, $ab = -\mathrm{Q}$.

If a and b come out impossible quantities, the exponents of a and b in the value of y will have the form

$$a = \alpha + \beta\sqrt{-1},\quad b = \alpha - \beta\sqrt{-1};$$

we have then

$$y = \mathrm{C}e^{\alpha x + \beta x\sqrt{-1}} + \mathrm{C}'e^{\alpha x - \beta x\sqrt{-1}}$$
$$= e^{\alpha x}\left(\mathrm{C}^{\beta x\sqrt{-1}} + \mathrm{C}'e^{-\beta x\sqrt{-1}}\right);$$

This result is rendered real by eliminating the imaginary quantities, by means of sines and cosines; thus we have (ALGEBRA, art. 269),

$$e^{\beta x\sqrt{-1}} = \cos\beta x + \sqrt{-1}\sin\beta x,$$
$$e^{-\beta x\sqrt{-1}} = \cos\beta x - \sqrt{-1}\sin\beta x,$$
$$y = e^{\alpha x}\{(\mathrm{C}+\mathrm{C}')\cos\beta x + (\mathrm{C}-\mathrm{C}')\sqrt{-1}\sin\beta x\};$$

and making $\mathrm{C}+\mathrm{C}' = c$, $(c - c')\sqrt{-1} = c'$,

$$y = e^{\alpha x}\,(c\cos\beta x + c'\sin\beta x);$$

or, making $c = p\sin q$, $c' = p\cos q$,

$$y = pe^{\alpha x}\sin(\beta x + x).$$

When the roots a and b are equal, the value of y being reduced to

$$\mathrm{C}e^{ax} + \mathrm{C}'e^{ax} = (\mathrm{C} + \mathrm{C}')e^{ax},$$

it becomes incomplete. In this case we may proceed, as in art. 58, by supposing that a and b differ by a very small quantity. Let us suppose that $b = a + k$, there thence results

$$y = \mathrm{C}e^{ax} + \mathrm{C}'e^{ax+kx} = e^{ax}\,(\mathrm{C} + \mathrm{C}'e^{kx}):$$

developing e^{kx} according to the powers of k, we have

$$y = e^{ax}(\mathrm{C} + \mathrm{C}' + \mathrm{C}'kx + \mathrm{C}'\frac{k^2x^2}{2} + \&\text{c.})$$

or, putting $\mathrm{C} + \mathrm{C}' = c$ and $c'k = c'$

$$y = e^{ax}(c + c'x + c'k\frac{x^2}{2} + \&\text{c.})$$

This last expression, which satisfies the proposed equation for all values of k, agrees with it likewise if $k = 0$, or $b = a$; and, in that case, it becomes

$$y = e^{ax}(c + c'x).$$

190. When P and Q are variable quantities, functions of x, then if v and v' are two values of y which each satisfy the equation

$$\frac{d^2y}{dx^2} + \mathrm{P}\frac{dy}{dx} + \mathrm{Q}dy = 0,$$

we may take

$$y = cv + c'v$$

for the complete primitive equation. For then $dy = cdv + cdv'$, $d^2y = cd^2v + cd^2v$, and the differential equation becomes

$$c\left(\frac{d^2v}{dx^2} + \mathrm{P}\frac{dv}{dx} + \mathrm{Q}v\right) + c',\left(\frac{d^2v}{dx^2} + \frac{dv'}{dx} + \mathrm{Q}v'\right) = 0.$$

Now, by hypothesis,

$$\frac{d^2v}{dx^2} + \mathrm{P}\frac{dv}{dx} + \mathrm{Q}v = 0;\ \frac{d^2v'}{dx^2} + \mathrm{P}\frac{dv'}{dx} + \mathrm{Q}dv' = 0.$$

Therefore the equation is identical, and so the value of y is truly determined.

As an example of the integration of a differential equation of the second degree, see the article ARCH (art. 57).

191. We shall now give an example of the integration of a differential equation of the first degree and the second order.

Let the equation be

$$d^2y + ax^nydx^2 = 0.$$

If we suppose

$$y = \mathrm{A}x^{\alpha} + \mathrm{B}x^{\alpha+\delta} + \mathrm{C}x^{\alpha+2\delta} + \&\text{c.}$$

and that the series of exponents is an increasing one, or that δ is positive, we may, when x is supposed very small, conceive y to reduce itself to its first term, since the others are too small to be compared with this first. On this supposition, we may confine ourselves to assuming

$$y = \mathrm{A}x^{\alpha};\ \text{then}\ d^2y = \alpha\,(\alpha - 1)\,\mathrm{A}x^{\alpha-2}\,dx^2,$$

and the proposed equation will become

$$\alpha(\alpha - 1)\,\mathrm{A}x^{\alpha-2} + a\mathrm{A}x^{\alpha+n} = 0.$$

It is not possible to determine α so as to make the two exponents $\alpha - 2$ and $\alpha + n$ equal, except in the particular case of $n = -2$; but the exponent of x being greater in the second term than the first, we may neglect one of these terms in comparison with the other; and the equation may then be verified in two ways (by approximation), viz. by making $\alpha = 0$, and $\alpha = 1$, since upon either hypothesis the term $\alpha(\alpha - 1)\,\mathrm{A}x^{\alpha - 2}$ (the greatest in the equation) vanishes: A, therefore, remains indeterminate, and we have two series, one beginning with A, and the other with Ax.

If we take successively

$$y = \mathrm{A} + \mathrm{B}x^{\delta} + cx^{2\delta} + \&c.$$

$$y = \mathrm{A}x^{1+\delta} + \mathrm{B}x^{1+2\delta} + cx^{1+2\delta} + \&c.$$

and substitute for y these values, and for d^2y its corresponding values, we shall then find, by properly arranging the terms, that δ must be $= 2$; and, in either case, determining the values of the co-efficients A, B, C, &c. we arrive at these two series,

$$\mathrm{A} - \frac{a\mathrm{A}x^{n+2}}{(n+1)(n+2)} + \frac{a^2\mathrm{A}x^{2n+4}}{(n+1)(n+2)(2n+3)(2n+4)}$$
$$- \frac{a^3\mathrm{A}x^{3n+6}}{(n+1)(n+2)(2n+3)(2n+4)(3n+5)(3n+6)} + \&c.$$

$$\mathrm{A}x - \frac{a\mathrm{A}x^{n+3}}{(n+2)(n+3)} + \frac{a^2\mathrm{A}x^{2n+5}}{(n+2)(n+3)(2n+4)(2n+5)}$$
$$- \frac{a^3\mathrm{A}^{3n+7}}{(n+2)(n+3)(2n+4)(2n+5)(3n+6)(3n+7)} + \&c.$$

These developments are only particular cases, since they contain each but one arbitrary constant A; but, on account of the particular form of the proposed example (189), we shall obtain a general expression for y, by writing in the latter of them A_1 for A, and taking their sum.

Having now given as full a view of the principles of the fluxional calculus as we conceive to be compatible with the nature of our work, we shall conclude with a few more examples of its application to geometry.

Problem 1.

To find the length of the enlarged meridian in *Mercator's*, or rather *Wright's* projection of the sphere.

In this projection, the meridians and parallels of latitude are straight lines, which intersect each other at right angles; and the projection of any small arc of a meridian (as one minute), reckoned from any parallel, is to the projection of a like arc of longitude in that parallel, as radius to the cosine of the latitude of the parallel, that is, in the same ratio as the arcs themselves in the sphere. Supposing the radius of the sphere to be unity, let v be any arc of latitude reckoned from the equator, z its projection on the chart, or the *enlarged meridian.* Let v' and z' be any small increments of v and z; then, by the principles of the projection, $\frac{z'}{v'} = \frac{rad}{\cos v}$; therefore, putting the ratio of the differentials for the limit of the ratio of the increments, $\frac{dz}{dv} = \frac{1}{\cos v}$, and $dz = \frac{dv}{\cos v}$. Therefore, taking the integral (art. 155), $z = \mathrm{l.}\,\{\tan(45° + \frac{1}{2}v)\}$. Here no correction is wanted, because when $v = 0$, then $z = \mathrm{l.}\,(\tan 45°) = \mathrm{l.}\,(1) = 0$, as it should be.

Henry Bond, in the year 1650, discovered, by chance, that the enlarged meridian might be expressed by the logarithmic tangents of half the complements of the latitudes, a rule easily found from the preceding solution; but the difficulty of proving this was then considered so great, that Mercator offered to wager a sum of money against any person that should undertake to prove it either true or false. James Gregory, however, proved it in his *Exercitationes Geometricæ*, published in 1668; also Barrow, in his Geometrical Lectures: their demonstrations, however, were intricate. Afterwards Dr Wallis and Dr Halley gave demonstrations which were sufficiently simple and elegant.

Inverse Method.

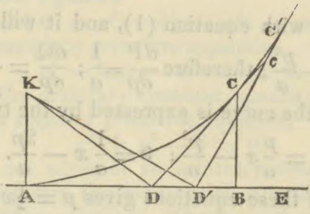
Problem 2.

If any number of straight lines are drawn according to some determinate law, it is required to find the nature of a curve to which these are tangents.

For example, let AE be a straight line given by position, and K a given point without it; let any number of lines KD, KD′, &c. be drawn to meet AE in D, D′, &c.; and let perpendiculars DC, D′C′, &c. be drawn to these lines; it is required to find the nature of the curve ACC′, to which these perpendiculars are tangents.

Without attending to the particular case, we shall resolve the general problem, and suppose AE to be the axis of the curve, A being the origin of the co-ordinates, and CD any position of the tangent, which meets the axis in D. From the point of contact C draw the perpendicular CB; and, considering C as a point in the curve, put AB $= x$, BC $= y$; but again considering C as any point whatever in the tangent, put AB $= x'$, BC $= y'$. Then, whatever be the conditions that determine the position of the tangent, the relation of x' and y', the co-ordinates of any point in it, may be expressed by the equation $y' = \mathrm{P}x' + \mathrm{Q}$, where P and Q are put to denote generally certain functions of constant quantities, and some quantity p, which has the same value for any given position of the tangent, but which changes its value if the tangent changes its position. For example, p may express the angle which the tangent makes with the axis, or it may represent the subtangent BD, &c.

Fig. 33.



Let us now suppose that the variable quantity p changes its value, and becomes $p + h$, and that C′ D′ is the new position of the tangent corresponding to $p + h$; then, considering P and Q as functions of p, by Taylor's theorem (art. 31),

$$\mathrm{P \ becomes \ P} + \frac{d\mathrm{P}}{dp}h + \frac{d^2\mathrm{P}}{dp^2}\frac{h^2}{2} + \&c.$$

$$\mathrm{Q \ becomes \ Q} + \frac{d\mathrm{Q}}{dp}h + \frac{d^2\mathrm{Q}}{dp^2}\frac{h^2}{2} + \&c.$$

The relation of x' to y' in the new position of the tangent will now be expressed by the equation

$$y' = \mathrm{P}x' + \mathrm{Q} + \left(\frac{d\mathrm{P}}{dp}x' + \frac{d\mathrm{Q}}{dp}\right)h + \mathrm{K}h^2 + \&c.$$

Where $\mathrm{K}h^2$ + &c. is put for all the remaining terms of the series.

Now, as this equation holds true of every point in the

Inverse Method.

tangent C′ D′, and the equation $y' = \mathrm{P}x' + \mathrm{Q}$ holds true of every point in the tangent CD, it follows that at c, the intersection of the two tangents, both equations must be true at the same time; therefore at c we have

$$\left(\frac{d\mathrm{P}}{dp}x' + \frac{d\mathrm{Q}}{dp}\right)h + \mathrm{K}h^2 + \&\text{c.} = 0;$$

and, dividing by h, $\frac{d\mathrm{P}}{dp}x' + \frac{d\mathrm{Q}}{dp} + \mathrm{K}h + \&\text{c.} = 0.$

Conceive now the two tangents to approach to coincidence; when C′ comes to C, then c will also fall at C; and h, and all the terms into which it enters, vanish; also x' and y' become x and y: and, to determine the nature of the curve, we have these two equations:

$$y = \mathrm{P}x + \mathrm{Q} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$0 = \frac{d\mathrm{P}}{dp}x + \frac{d\mathrm{Q}}{dp} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

By eliminating p from these, the resulting equation will express the nature of the curve.

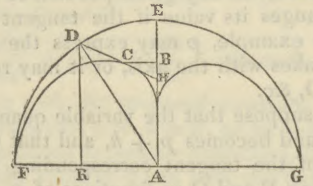
Ex. 1. Let us now recur to the particular case of AE, a straight line given by position, K a given point, and KDC a right angle: Draw KA perpendicular to AE; put $\mathrm{AB} = x$, $\mathrm{BC} = y$, $\mathrm{KA} = a$, and let AD be the variable quantity p. The triangles KAD, DBC are manifestly similar; therefore KA : AD = DB : BC, that is, $a : p = x - p : y$; hence $ay = px - p^2$, and $y = \frac{p}{a}x - \frac{p^2}{a}.$ Compare this with equation (1), and it will appear that $\mathrm{P} = \frac{p}{a}$, $\mathrm{Q} = -\frac{p^2}{a}$; therefore $\frac{d\mathrm{P}}{dp} = \frac{1}{a}$; $\frac{d\mathrm{Q}}{dp} = -\frac{2p}{a}$; hence the nature of the curve is expressed by the two equations

$$y = \frac{p}{a}x - \frac{p^2}{a};\ \ 0 = \frac{1}{a}x - \frac{2p}{a}.$$

The second of these equations gives $p = \frac{1}{2}x$; and hence the first becomes $y = \frac{x^2}{2a} - \frac{x^2}{4a}$; therefore $4\,ay = x^2$ is the equation of the curve, which is evidently a parabola, of which AK is the axis, K the focus, and A the vertex.

Ex. 2. Suppose a ray of light RD, coming from the sun, to fall upon FEG, the concave surface of a sphere, at D, and to be thence reflected in the direction DH; it is proposed to find the nature of the curve to which this, and all rays reflected in the same manner, are tangents.

Fig. 34.



Draw AD the radius of the sphere, and AE parallel to the incident ray RD; let C be the point in which the reflected ray touches the curve; let DC meet AE in H, and draw CB perpendicular to AE. Put $\mathrm{AD} = a$, $\mathrm{AB} = x$, $\mathrm{BC} = y$, and let p be the variable angle DAE.

By the principles of optics, AD bisects the angle RDH, which is equal to DHE, that is, to the sum of the angles DAH, ADH; therefore the angles ADH, DAH are equal, and angle $\mathrm{DHE} = 2p$. Now, by trigonometry,

$$\mathrm{AH} = \frac{\sin \mathrm{ADH}}{\sin \mathrm{AHD}} \times \mathrm{AD} = \frac{\sin p}{\sin 2p}\,a,$$

$$\mathrm{BH} = \frac{\cos \mathrm{CHB}}{\sin \mathrm{CHB}} \times \mathrm{CB} = \frac{\cos 2p}{\sin 2p}\,y;$$

$$\text{Hence } x = (\mathrm{AH} + \mathrm{BH}) = \frac{\sin p}{\sin 2p}\,a + \frac{\cos 2p}{\sin 2p}\,y,$$

$$\text{and } y = \frac{\sin 2p}{\cos 2p}\,x - \frac{\sin p}{\cos 2p}\,a \ldots\ldots\ldots\ldots\ldots\ldots (\alpha)$$

By comparing this with the general formula (1), it appears that

$$\mathrm{P} = \frac{\sin 2p}{\cos 2p},\ \mathrm{Q} = -\frac{\sin p}{\cos 2p}\,a;\ \text{hence,}$$

$$\frac{d\mathrm{P}}{dp} = \frac{2}{\cos^2 2p},\ \frac{d\mathrm{Q}}{dp} = -\frac{\cos p}{\cos 2p}\,a - \frac{2 \sin 2p \sin p}{\cos^2 2p}\,a.$$

Hence, by formula (2),

$$\frac{2x}{\cos^2 2p} = \left\{\frac{\cos p}{\cos 2p} + \frac{2 \sin 2p \sin p}{\cos^2 2p}\right\}a \ldots\ldots\ldots (\beta)$$

From equations (α) and (β) we readily find

$$x = (\tfrac{1}{2} \cos 2p \cos p + \sin 2p \sin p)\,a,$$

$$y = (\tfrac{1}{2} \sin 2p \cos p - \cos 2p \sin p)\,a;$$

and hence, by observing that $\sin 2p = 2 \sin p \cos p$, and that $\cos 2p = 2 \cos^2 p - 1 = 1 - 2 \sin^2 p$ (*Arithmetic of Sines*, ALGEBRA), we have also

$$x = \tfrac{1}{2} \cos p\,(1 + 2 \sin^2 p)\,a;\ \ y = \sin^3 pa.$$

From these equations it is easy to eliminate the trigonometrical quantities cos p and sin p, and the result will be the equation of the curve, which is an epicycloid. The curve in question is the *catacaustic* curve to a circle.

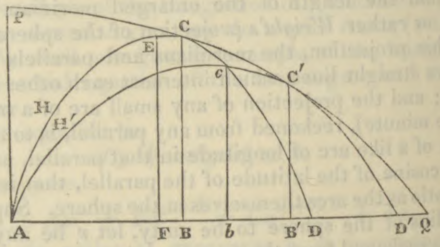
It is easy to see that the general problem, of which we have now given two examples, is very comprehensive. We may evidently find, by the formulæ (1) and (2), *catacaustic* and *diacaustic* curves in all cases whatever. These, and an infinite number of other geometrical problems, are contained in the following more general problem.

Problem 3.

Determine the nature of a curve which touches an infinite number of lines of a given kind, described upon a plane according to some determinate law. For example, suppose the lines to be parabolas described by a projectile thrown from an engine with a given velocity, at every possible elevation in a vertical plane.

Let HCD be any one of the lines of a given kind (a parabola, for example), and suppose it referred to an axis AB, by the rectangular co-ordinates $\mathrm{AB} = x'$ and $\mathrm{BC} = y'$. Let p denote some quantity belonging to the line or curve HCD, which has always the same value in the same curve, but which has different values in different curves. Thus, if the curve be a circle, p may be its radius; or if the curve be a parabola, p may be its parameter, &c. This quantity p may also by analogy be called the *parameter* of the curve HCD. Let us suppose the nature of this curve to be expressed by the equation

Fig. 35.



$$f(x', y', p) = 0 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

that is, let some function of x', y', and p, be supposed $= 0$. If p now be supposed to change its value, and become $p + h$, then the curve HCD will change its figure, and have some other position H′C′D′. Let $\mathrm{AB}' = x''$, and B′C′

$= y''$, be any co-ordinates of this other curve, and as, by hypothesis, the two curves are expressed by equations of the same form, we must have

$$f(x'', y'', p+h) = 0;$$

and this expression, by Taylor's theorem, is equivalent to

(2)

$$f(x'', y'', p) + \frac{d\{f(x'', y'', p)\}}{dp}h + \mathrm{K}h^2 + \&c.,$$

the differential being taken upon the hypothesis that p alone is variable, and $\mathrm{K}h^2 + \&c.$ being put for all terms of the series following the second, each of which is multiplied by a power of h.

Let the two curves intersect each other in c, and let $\mathrm{A}b = x$, and $cb = y$, be the common co-ordinates; then, as equation (1) holds true of every point in the curve HCD, and equation (2) holds true of every point in H′C′D′, both must hold true at once, if we substitute in them x and y, the co-ordinates belonging to their common point c; that is, we must have

$$f(x, y, p) = 0,$$

$$f(x, y, p) + \frac{d\{f(x, y, p)\}}{dp}h + \mathrm{K}h^2 + \&c. = 0;$$

and hence we must also have

$$\frac{d\{f(x, y, p)\}}{dp} + \mathrm{K}h + \&c. = 0.$$

Let C and C′ be now supposed the points in which the curves HcD, H′cD′ touch the curve PCC′Q, whose nature is required; then, if we suppose h to decrease continually, and at last to vanish, the points C′ and c will approach to C, and at last will coincide with it, so that x and y, which are co-ordinates of c, the intersection of the two curves HcD, H′cD′, will then become the co-ordinates of the curve PCQ. As all the terms which contain h will then vanish, we have evidently this rule.

Let the equation of the given curves be

$$f(x, y, p) = 0 \ldots\ldots\ldots\ldots\ldots\ldots(\alpha)$$

x and y being the co-ordinates, and p a variable parameter. From this equation, by taking the differential, supposing p to be variable, and all the other quantities constant, we deduce this other equation,

$$\frac{d\{f(x, y, p)\}}{dp} = 0 \ldots\ldots\ldots(\beta)$$

By these eliminate p, and the result will be an equation, which expresses the nature of the curve that touches all the given curves.

Ex. Let ACD, AC′D′, &c. be parabolas described by a projectile thrown from a given point A, with a given velocity, in a given vertical plane. It is proposed to find the curve PCQ which touches them all. Let EF be the axis of any one of the curves, AD an ordinate to the axis, $\mathrm{AP} = a$ the height due to the velocity of projection, $\mathrm{AB} = x$, $\mathrm{BC} = y$, the co-ordinates of C, any point in the curve. Put the parameter of the axis $= p$, and considering AD as a function of p, which is to be regarded as variable, put $\mathrm{AD} = q$.

By the theory of projectiles, $\mathrm{EF} = a - \frac{1}{4}p$, and by the nature of the parabola, $\mathrm{AF}^2 = p \times \mathrm{EF}$, and $\mathrm{AB} \times \mathrm{BD} = p \times \mathrm{BC}$; hence we have these two equations,

$$qx - x^2 = py, \ (1) \qquad q^2 = 4ap - p^2, \ (2)$$

From the first of these,

$$f(x, y, p) = x^2 + py - qx = 0:$$

and, taking the differentials, considering x and y as constant, and q as a function of the variable quantity p,

$$\frac{d\{f(x, y, p)\}}{dp} = y - \frac{dq}{dp}x = 0,$$

therefore $\frac{y}{x} = \frac{dq}{dp}$; but from equation (2), taking the differentials, $qdq = 2adp - pdp$, and hence $\frac{dq}{dp} = \frac{2a-p}{q}$, and by the first equation $\frac{y}{x} = \frac{q-x}{p}$, therefore $\frac{q-x}{p} = \frac{2a-p}{q}$, and hence $q^2 - qx = 2ap - p^2$; and substituting for q^2 its value given by equation (2), we get $qx = 2ap$; hence, and by equation (1),

$$p = \frac{x^2}{2a - y}, \qquad q = \frac{2ax}{2a - y}.$$

These values of p and q being substituted in the second equation, and the common denominator rejected, it becomes

$$4a^2x^2 = (8a^2 - 4ay - x^2)x^2.$$

Hence $4ay = 4a^2 - x^2$, and this is the equation of the curve PCQ, which is evidently a parabola having its focus at A, the common intersection of all the parabolas, its axis perpendicular to the horizon, and its parameter $= 4a$.

The geometrical theory comprehended in the second and third problems has a corresponding analytical theory relating to the integrals of certain differential equations. This is the theory of *singular* primitive equations, which are not included in the *complete* primitive equation. Thus, the differential equation

$$dy\sqrt{(x^2 + y^2 - b)} - ydx - xdx = 0,$$

has for its complete primitive equation

$$x^2 - 2ay - a^2 - b = 0,$$

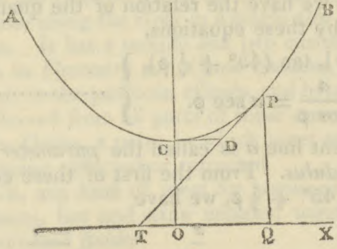
where a is the arbitrary constant quantity; but, besides this, it has a *singular* primitive equation,

$$x^2 + y^2 - b = 0,$$

which does not admit of an arbitrary constant, although it equally satisfies the differential equation, as is easily proved by differentiating. The bounds within which it was proper to confine this treatise have not allowed us to enter into this branch of the subject, which, although interesting, is yet not elementary.

Investigation of the Properties of the Catenary.

Suppose a chain or thread of uniform thickness, and perfectly flexible, but inextensible, to be fastened by its extremities at two points A, B in a vertical plane; by the action of gravity it will take the form of a curve ACPB, called the *catenary*.



The curve will evidently be all in one plane, and a horizontal line CD, in that plane, at C its lowest point, will manifestly touch the curve, which is retained at rest by a mutual balancing of the forces produced by the weight of the particles of the chain.

If we suppose its lowest point to be fixed at C, it is easy to understand that the part BC will not on that account change in the least its figure, because the tension of the chain at C, when it was free, is now replaced by the reaction of the force exerted in the horizontal direction CD.

Inverse Method.

The forces exerted on the points B, C will evidently be the same in quantity and in direction, whether the chain be considered as flexible, or rigid like a solid wire; hence it may be regarded as kept at rest by three forces, viz. its gravity acting vertically, and the re-actions of the tensions at B and C; the former exerted in the direction of a tangent to the curve at B, and the latter in the direction CD, the tangent at the lowest point C.

In like manner any portion PC between P and its lowest point may be considered as kept at rest by the joint action of the gravity of the mass PC, the tension of the chain at C, which is constant, and the tension at P, which is variable; and by the nature of an equilibrium (MECHANICS), these forces will be to each other as the sides of any triangle which are parallel to their directions. Draw a horizontal line OX in the plane of the curve as an axis, meeting the vertical through C in O, which may be taken as an origin of co-ordinates; draw PQ perpendicular to OX, and PT touching the curve and meeting the axis in T. From what has been explained, the tension of the curve at C will be to the weight of the matter in PC as TQ to PQ, that is, as radius to the tangent of the angle which PT makes with any horizontal line.

Put $OQ = x$, $PQ = y$, arc $CP = z$, angle $PTQ = \varphi$; and let a be the tension of the curve at the vertex C: we have then $a : z = 1 : \tan \varphi$; hence

$$\tan \varphi = \frac{z}{a} \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

This is the distinguishing property of the curve, from which we are to deduce its other properties.

From equation (1), by differentiation,

$$\frac{d\varphi}{\cos^2 \varphi} = \frac{dz}{a}.$$

Now in all curves,

$$dz = \frac{dx}{\cos \varphi} = \frac{dy}{\sin \varphi};$$

hence we obtain

$$dx = a \,.\, \frac{d\varphi}{\cos \varphi}, \quad dy = a \,.\, \frac{d\varphi \sin \varphi}{\cos \varphi}.$$

From these, by integration,

$$x = a \, \text{l.} \tan (45° + \tfrac{1}{2} \varphi) + \text{const. (art. 155)}$$

$$y = \frac{a}{\cos \varphi} + \text{const.}$$

If we assume that OC measures the tension at C, which is a constant quantity, then because when $\varphi = 0$, $x = 0$, and $y = a$, we have the relation of the quantities x, y, φ, expressed by these equations,

$$\left.\begin{array}{l} x = a \, \text{l.} \tan (45° + \tfrac{1}{2} \varphi), \\ y = \dfrac{a}{\cos \varphi} = a \sec \varphi. \end{array}\right\} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The constant line a is called the *parameter* of the curve, also its *modulus*. From the first of these equations, putting ψ for $45° + \frac{1}{2} \varphi$, we have

$$\tan \psi = e^{\frac{x}{a}}, \quad \cot \psi = e^{\frac{-x}{a}},$$

$$\tan \psi + \cot \psi = e^{\frac{x}{a}} + e^{\frac{-x}{a}}.$$

Now, $\tan \psi + \cot \psi = \dfrac{\sin \psi}{\cos \psi} + \dfrac{\cos \psi}{\sin \psi}$,

$$= \frac{2}{\sin 2 \psi} = \frac{2}{\cos \varphi} = \frac{2y}{a};$$

$$\text{therefore } y = \frac{a}{2} \left\{ e^{\frac{x}{a}} + e^{\frac{-x}{a}} \right\} \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

This exponential equation expresses the relation between x and y by means of e, the base of Napier's logarithms. From this last equation, observing that $y = a \sec \varphi$, we get

$$\sec^2 \varphi = \tfrac{1}{4} \left\{ e^{\frac{2x}{a}} + e^{\frac{-2x}{a}} + 2 \right\},$$

$$\sec^2 \varphi - 1 = \tfrac{1}{4} \left\{ e^{\frac{2x}{a}} + e^{\frac{-2x}{a}} - 2 \right\},$$

$$\tan \varphi = \sqrt{\sec^2 \varphi - 1} = \tfrac{1}{2} \left\{ e^{\frac{x}{a}} - e^{\frac{-x}{a}} \right\}.$$

But it was found that $z = a \tan \varphi$,

$$\text{therefore } z = \frac{a}{2} \left\{ e^{\frac{x}{a}} - e^{\frac{-x}{a}} \right\} \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

From formulæ (3) and (4) we have

$$y + z = ae^{\frac{x}{a}}, \quad y - z = ae^{\frac{-x}{a}} \ldots\ldots\ldots(5)$$

$$\text{therefore } y^2 - z^2 = a^2 \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

hence again,

$$y = \sqrt{a^2 + z^2}, \; z = \sqrt{y^2 - a^2} \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

and since from formula (5)

$$\frac{x}{a} = \text{l.} \frac{y + z}{a} = \text{l.} \frac{a}{y - z} \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\text{therefore also, } \frac{x}{a} \left\{ \begin{array}{l} = \text{l.} \dfrac{y + \sqrt{y^2 - a^2}}{a} \\ = \text{l.} \dfrac{z + \sqrt{z^2 + a^2}}{a} \end{array} \right\} \ldots\ldots\ldots(9)$$

Let s denote the area bounded by the arc PC and the straight lines CO, OQ, PQ; then, since $dx = \dfrac{a d\varphi}{\cos \varphi}$, and $y = \dfrac{a}{\cos \varphi}$, therefore

$$ds = y dx = \frac{a^2 d\varphi}{\cos^2 \varphi} = a dz.$$

$$\text{and } s = az \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

Thus it appears that the arc CP is always proportional to the conterminous area CPQA. It is evident that the catenary, if inverted, would form an equilibrated arch. From this property it appears that if a wall, whose height above the crown of the arch is equal to the line CO, be horizontal at the top, the structure thus formed will constitute an equilibrated arch with a straight roadway. (See on this subject our article ARCH.) (R.)

FLY, a term usually applied to two-winged insects. See *Diptera*, in ENTOMOLOGY, *Index*.

FLY, in *Mechanics*, a cross with leaden weights at its ends; or rather, a heavy wheel at right angles to the axis of a windlass, jack, or the like, by means of which the force of the power, whatever it be, is not only preserved, but equally distributed in all parts of the revolution of the machine. See MECHANICS.

FLY ISLAND, an island in the South Pacific Ocean, discovered by De Maire and Schouten in 1616, and so named from the number of flies which were seen in it. Long. 150. 20. W. Lat. 15. S.

FLY TREE, in *Natural History*, a name given by the common people of America to a tree, the leaves of which, at a certain time of the year, are said to produce *flies*. On examining these leaves about the middle of summer there are found on them a sort of bags of a tough matter, of about the size of a filbert, and of a dusky greenish colour. On opening one of these bags with a knife, there is usually found a single full-grown fly, of the gnat kind, and a number of small worms, which in a day or two more have wings, and fly away in the form of their parent. The tree is of the mulberry kind, and its leaves are for the most part largely stocked with these insect bags; but they are generally found to contain the insects in their worm state; and when these become winged, they soon make their way out. The bags begin to appear when the leaves are young, and afterwards grow with them; but they never rumple the leaf or injure its shape. They are of the kind of leaf-galls, and partake in all respects, except size, of a species which is frequent on the large maple, or, as it is called, the *sycamore*.

FLYERS, the performers in a celebrated exhibition amongst the Mexicans, made on certain great festivals, which are described by Clavigero in his history of that people.

FLYING, the progressive motion of a bird, or other winged animal, through the air.

The parts of birds chiefly concerned in flying are the wings and tail; by the former the bird sustains and wafts itself along, and by the latter it is assisted in ascending and descending, keeping its body poised and upright, and obviating vacillations. It is by the size and strength of the pectoral muscles that birds are so well disposed for quick, strong, and continued flying. These muscles, which in men are scarcely a seventieth part of the muscles of the body, in birds exceed and outweigh all the other muscles taken together; so that if it were possible for a man to fly, his wings must be so contrived and adapted that he may make use of his legs, and not his arms, in managing them.

The tail is supposed by Willoughby, Ray, and others, to be principally employed in steering and turning the body in the air, like a rudder; but Borelli has put it beyond all doubt that this is the least use of the tail, which is chiefly intended to assist the bird in its ascent and descent in the air, and to obviate the vacillations of the body and wings; for as to turning to this or that side, that is performed by the wings and inclination of the body, with but very little help from the tail. The flying of a bird is in fact quite a different thing from the rowing of a vessel. Birds do not vibrate their wings towards the tail, as oars are struck towards the stern, but waft them downwards; nor does the tail of the bird cut the air at right angles as the rudder does the water, but is disposed horizontally, and preserves the same situation whichever way the bird turns. In fact, as a vessel is turned on a centre of gravity to the right, by a brisk application of the oars to the left, so a bird, in beating the air with its right wing alone towards the tail, will turn its fore part to the left. Thus pigeons changing their course to the left, would labour it with their right wing, keeping the other almost at rest. Birds of a long neck alter their course by the inclination of their head and neck; which altering the course of gravity, enables the bird to proceed in a new direction.

Artificial FLYING, that which is attempted by men, by means of mechanical contrivances.

The art of flying has been attempted by various persons in all ages. The superstitious Leucadians are reported to have had a custom of precipitating a man from a high cliff into the sea, first fixing feathers, variously expanded, round his body, in order to break his fall.

Friar Bacon not only affirms that the art of flying is possible, but assures us that he himself knew how to make a machine in which a man sitting might be able to convey himself through the air like a bird; and he further adds, that there was then a person who had tried it with success. The secret consisted in a couple of large thin hollow copper globes, exhausted of air; which being much lighter than common air, would sustain a chair on which a person might sit and be buoyed along. Father Francisco Lana, in his *Prodromo*, proposes the same thing. He computes, that a round vessel of plate brass, fourteen feet in diameter, weighing three ounces the square foot, will only weigh 1848 ounces, whereas a quantity of air of the same bulk will weigh $2155\frac{2}{3}$ ounces; so that the globe will not only be sustained in the air, but will carry with it a weight of $373\frac{2}{3}$ ounces; and by increasing the bulk of the globe without increasing the thickness of the metal, he conceives that a vessel might be made to carry a much greater weight. But the fallacy is obvious. A globe of the dimensions he describes, as shown by Dr Hook, would not sustain the pressure of the air, but be crushed inwards. Besides, in whatever ratio the bulk of the globe were increased, in the same ratio must the thickness of the metal, and consequently the weight, be increased; so that there would be no advantage in such augmentation.

The philosophers of the reign of Charles II. were mightily busied about this art. The celebrated Bishop Wilkins was so confident of success in the attempt, that he says he does not question but in future ages it will be as usual to hear a man call for his wings when he is going a journey, as it is now to call for his boots.

FLYING Fish, a name given to several species of fishes, which, by means of long fins, can keep themselves out of the water for some time. See ICHTHYOLOGY.

FOAL, or *COLT and FILLY*, the young of the horse kind. The word *colt*, among dealers, is understood of the male, and *filly* of the female.

FOCHAN, a town of China, near Canton, situated on the banks of the river on which the city stands, and extending three miles along the river in a single row of large well-built houses. It has a temple and two custom-houses.

FOCUS, in *Geometry* and *Conic Sections*, is applied to certain points in the parabola, ellipsis, and hyperbola, where the rays reflected from all parts of these curves meet.

FOCUS, in *Optics*, a point in which meet any number of rays, after being reflected or refracted.

FODDER, any kind of meat for horses or other cattle. In some places, hay and straw mingled together is peculiarly denominated *fodder*.

FŒNUS NAUTICUM. Where money was lent to a merchant to be employed in a beneficial trade, on condition of being repaid with extraordinary interest, in case such voyage was safely performed, the agreement was sometimes called *fœnus nauticum*, sometimes *usura maritima*.

FŒTOR, in *Medicine*, fœtid effluvia arising from the body, or any part thereof.

FŒTUS, the young of all viviparous animals whilst in the womb, and of oviparous animals before being hatched. The name is transferred by botanists to the embryons of vegetables. See ANATOMY.

FOG, or MIST, signifies the gross vapours floating near the surface of the earth. See METEOROLOGY.

FOGARAS, a market-town situated on the river Alt, in Hungary, the chief place of a district of the same name, in the division of the Seven Mountains. It contains a Catholic, a Lutheran, a Reformed, and two Greek churches, and 3200 inhabitants. Long. 24. 55. 9. E. Lat. 45. 48. 47. N.

FOGGIA, a city of the kingdom of Naples, the capital of the province Capilanata. It stands on an extensive plain, where several roads from the interior meet. It is extensive, has broad streets, and is surrounded with walls. It has several large fairs and markets, upon which the prosperity of the city chiefly depends. There are here several large magazines for storing corn, which is one of the chief branches of its trade. It is remarkable for the growth and preservation of capers, and produces abundance of wine and oil. It contains 20,680 inhabitants. Long. 15. 38. E. Lat. 41. 25. N.

FOHR, or FORA, an island belonging to the kingdom of Denmark, in the German Ocean, near the mouth of the river Illwe. It extends in north latitude from 54. 41. to 54. 46. and in east longitude from 8. 19. to 8. 31. It contains one market-town, called Westerlandfohr, and sixteen villages, forming sixteen parishes, and inhabited by 5670 persons, many of them sailors. A great number of the men are occupied in taking birds for the down and feathers, whilst the females make a large quantity of warm hosiery and gloves. They are said to have been originally a colony of Frisians, and still speak the language of that people.

FOIBLE, a French term, frequently used in our own language. It literally signifies *weak*, and in that sense is applied to the body and its parts, as *foible* reins, *foible* sight, and the like. It is derived from the Italian *fievole*, which again is the Latin *flebilis*, to be lamented or pitied. But it is chiefly used with us substantively, to denote a defect or flaw in a person or thing.

FOIL, in fencing, denotes a blunt sword, having a button at the end covered with leather, which is used in learning the art of fencing. See FENCING.

FOIL, amongst glass-grinders, a sheet of tin, with quicksilver, or the like, laid on the back of a looking-glass, to make it reflect.

FOIL, amongst jewellers, a thin leaf of metal placed under a precious stone, to make it look transparent, and give it an agreeable colour, either deep or pale.

FOIX, an arrondissement in the department of Arriège, in France, extending over 803 square miles. It is divided into eight cantons and 104 communes, inhabited by 78,280 individuals. The chief place, which gives name to the circle, is situated in a wide and fruitful valley, on the left bank of the Arriège. It is old and ill built, has some trade in hats, stockings, and caps, and contains 3600 inhabitants. Long. 1. 30. E. Lat. 43. 2. N.

FOKIEN, a large province of China. On the north it is bounded by the province of Tche-kiang, on the east by the Chinese Sea, on the south by Quang-tong, and on the west by Kiang-si. It comprehends under its jurisdiction the Pang-hon or Piscadore Islands, and also the island of Formosa. It has a fertile soil, and an agreeable, warm, and salubrious air; the mountains produce abundance of trees fit for ship-building; and agriculture is prosecuted with great skill on the plains, which yield rice in abundance. The high grounds are disposed in terraces, rising above one another, and water is conducted to them in pipes made of bamboo, which grows here in great plenty. The mountainous parts produce quicksilver, copper, lead, and iron; and it is even conjectured that there are gold mines, though these are not allowed to be worked. Manufactures are carried on in this province to a considerable extent. Steel implements are made, and also cloth from hemp and cotton, besides paper and pencils. The silks and cloth are of extraordinary fineness and beauty. The port of Enfouy in this province was formerly open to European vessels. The chief towns are Fou-tchoo, the capital, celebrated both for commerce and literature; Tsuen-tchosu, Yeu-ping, and Tchang-tcheou. The population is computed, though on very uncertain data, at 15,000,000.

FOKSCHANI, a city of Wallachia, in the circle Slam Rimnick, situated on the river Milkow. It contains fourteen churches and a monastery, with 4000 inhabitants, who trade in corn and cattle largely, and produce some good wine. Long. 26. 57. 25. E. Lat. 45. 38. 50. N.

FOLARD, JEAN-CHARLES DE, a distinguished French officer and military writer, descended of a noble but not affluent family, was born at Avignon on the 13th of February 1669. Even in his infancy he evinced a strong predilection for the profession of arms; and this inclination was confirmed by the perusal of Cæsar's *Commentaries*, which he received as a prize at the age of fifteen. In fact, he had scarcely attained his sixteenth year, when, making his escape from the paternal roof, he enlisted in a company of infantry which happened to be passing through Avignon; and although his father obtained his discharge, and shut him up in a convent, he again made his escape about two years thereafter, and shouldered a musket as a common soldier in the regiment of Berri. But his good conduct, as well as his birth, having soon brought him into notice, he obtained a sub-lieutenancy; and it was in this grade, the lowest of commissioned officers, that he saw service for the first time in the year 1688. Fortunately for his own improvement, however, he was employed in a corps of partisans, which, as all military men know, is the best school of instruction in great operations. Folard had thus occasion to observe, and to study with advantage, the most important branches of the military art. He examined all the communications, calculated the means of attack and defence, reconnoitred positions, constructed plans and maps, and thus, in short, prepared the materials of his voluminous works. It was during this period that he composed a little treatise entitled *De la Guerre de Partisan*, which has never been printed, but which Marshal de Belleisle long possessed in manuscript. The Marquis de Guébriant, colonel of the regiment of Berri, having taken a great interest in Folard, obtained for him a lieutenancy in his regiment; and immediately afterwards this corps received orders to proceed to Naples. It was during the long march which ensued that Folard, observing that the enemy received provisions and ammunition by sea, conceived the idea of surprising the post of Mesola, which protected the landing of the convoys. He accordingly submitted his plan to M. de Guébriant, by whom it was forwarded to the court, and there approved of; but another officer was charged with its execution, and the author remained unknown. The Duke of Vendôme, being informed of this injustice, appointed Folard his aid-de-camp, and at the same time procured for him the rank of captain. After giving him many proofs of confidence and esteem, this prince reluctantly consented to give up Folard to his brother, the Grand Prior, who then commanded in Lombardy. To the latter, Folard, ever zealous and active, rendered important services; but his talents, and above all his frankness, made him many enemies at head-quarters. He was at the taking of the posts of Rovero and Ostiglia, and also at the defence of the Casino della Bulino, where he distinguished himself greatly by his talents and his valour. It was by his advice that the Grand Prior caused this important post to be occupied; and Folard had, by the orders of his commander, repaired thither to make the necessary dispositions, when a numerous corps of the army of Prince Eugène appeared before it, with instructions to carry it at all hazards. The defensive preparations were still incomplete, and the garrison far from numerous; but, encouraged by Folard, they withstood the reiterated and furious attacks of the imperialists. The latter penetrated several times into the interior of the Casino; but by the intrepidity of the French, directed by Folard, they were each time repulsed, and ultimately compelled to discontinue their attacks. This brilliant affair, which procured him the cross of St Louis, is described by Folard in the notes to the third volume of his Polybius; and his relation has been cited by all military writers, not only as a model in itself, but also as containing one of the best lessons anywhere to be found on the defence of field-posts. Having rejoined the Duke of Vendôme, Folard rendered himself not less useful to that commander than he had previously done to the Grand Prior, and by his presence of mind, and the judicious advice which he gave at the battle of Cassano, fought on the 15th of August 1705, where he received two severe wounds, he acquitted himself as a brave soldier and skilful officer. This battle, remarkable for great efforts on both sides, for movements of all kinds, and for uncertain results, appears to have made a strong impression upon the imagination of Folard; and it is even said that amidst the suffering caused by his wounds he conceived his system of columns and deep formations. Soon after the battle of Cassano, Vendôme was ordered to proceed to Flanders, whither Folard, who was much attached to the duke, wished to accompany him; but he was retained with the army of Italy by the express desire of the Duke of Orleans, who had just assumed the command. The confidence which this prince reposed in him, and the freedom with which Folard continued to express his opinions, careless whom they might offend, once more made him dangerous enemies amongst the staff. From a note to Polybius it appears, indeed, that it was entirely owing to their insinuations that he received orders to shut himself up in Modena. It had become evident that this city would be attacked; and as the command was then in the hands of a person named Bar, upon whom no reliance could be placed, and who, in fact, had resolved to surrender the place at the first summons, the chevalier, firmly resolved to do his duty, soon found himself involved in serious disputes with this cowardly superior in command. In his *Traité de la Défense des Places*, he has given a long recital of the indignities he experienced at the hands of this miscreant, who even attempted his life; but although Folard unveiled his proceedings without reserve, the traitor escaped with impunity. Soon after the capitulation of Modena, the chevalier, to his great joy, received orders to join the Duke of Vendôme, who had in fact reclaimed his former aid-de-camp; and having taken Versailles in his way, he was there presented to the king, who received him graciously, and granted him a pension of four hundred francs. Upon his arrival in Flanders, Folard induced the Duke of Burgundy, then in command of the army, to attack the isle of Cadsand. The enterprise succeeded beyond all calculation, and its author was appointed commandant of the fort of Lettingen. But the young prince, who had at first appreciated the advice of the chevalier, afterwards paid as little regard to his opinions as to those of Vendôme; and, in spite of their joint remonstrances, he persisted in remaining inactive in presence of the allies, whilst Prince Eugène was engaged in taking Lille. The counsels which Folard gave to Marshal Villars for the relief of Mons were also disregarded. But his services were nevertheless recognised and appreciated at court; and it was about this time that the minister conferred on him a second pension of six hundred francs; a new favour, which was the more considerate, as he had been once more severely wounded at the battle of Malplaquet. Redoubling his zeal and activity, though no longer able to take part in the movements of the army, Folard followed them on the map and in his imagination, incessantly dreaming of plans and operations, and sending all his ideas to the generals. One day he caused himself be carried on a litter to the quarters of Marshal Boufflers, to give a piece of advice, which, however, was disregarded. Such zeal was no doubt indiscreet; and the manners of Folard were, it seems, calculated to injure the best observations. Thus M. de Montesquiou rejected the advice which the chevalier gave him respecting the position occupied by him at Douai; and it was only after his defeat that this general discovered his error in neglecting the counsels of the uncourtly chevalier. Some months afterwards Folard found Marshal Villars more docile; and he had the satisfaction of seeing the army put in motion, in consequence of a plan which he had transmitted to that general. Having subsequently been sent to M. de Guébriant, who occupied Aire, then threatened with a siege, he was taken prisoner on the road by the light troops of the enemy, who made vain attempts to discover the nature of his instructions. Prince Eugène, indeed, had recourse to every means of seduction in order to induce him to enter the service of the emperor; but Folard, immovable in his fidelity, resisted all these attempts, and even found an opportunity during his captivity of serving his sovereign, by misleading the prince as to the operations of the French army. As soon as he was exchanged, which the Duke of Burgundy lost no time in effecting, he obtained the command of the garrison of Burburg, the title and appointment of which he retained until his death.

The peace of 1712 having left him without active professional employment, Folard commenced his commentaries; but being still of an age not to remain long in a state of inaction, he profited by the alarms which the Ottomans occasioned to the knights of Malta in 1714, and, with the permission of the court, repaired to that island. The grand master received him with much cordiality; but Folard soon gave way to his characteristic vanity and indiscretion towards the French engineers, who, like himself, had come to offer the knights their best services for the defence of the island. Dissatisfied because his opinion had not prevailed, he refused the cross of the order, which was offered him, according to the ordinary usage in such cases, and immediately returned into France. But his warlike activity was not yet exhausted. The fame of the exploits of Charles XII. then resounded throughout all Europe, and Folard eagerly desired to witness the achievements of so celebrated a hero. Accordingly he embarked for Sweden on board a vessel, which was shipwrecked almost at the moment of landing; and having been saved in a sloop, he reached Stockholm destitute of every thing. The king, however, received him favourably, and listened to his discourses upon tactics with extreme complaisance. Nothing could possibly be more agreeable to Folard, who, delighted with his royal pupil, at once preferred Sweden to France as a place of residence for a soldier. Nevertheless he soon afterwards returned into his own country, for the purpose of promoting the plans of the Baron de Goërtz. But the project with which the baron was entrusted having been overthrown by his arrest, Folard returned to Stockholm, and accompanied the king of Sweden in his expedition to Norway. Immediately after the death of Charles before Frederickshall, he returned to France, and was promoted to the rank of colonel in the regiment of Picardy. In this capacity he served his last campaign in 1719, under the Duke of Berwick, in the short war which France had then to maintain in Spain. A general peace speedily ensued, and Folard then saw himself condemned to a state of repose, which as yet he had never known or enjoyed.

From this time he devoted himself entirely to his literary pursuits, and was ere long in a condition to present to the

Duke of Orleans, then regent, his book entitled *Nouvelles Découvertes sur la Guerre*, published at Paris in 1724. His next aim was to find a subject with which it might be possible for him to connect the results of his lengthened observations, and also to combine the explanation of his new system. And with this view he made choice of the history of Polybius. That work is, without any doubt, the most exact, and at the same time the most judicious, in a military point of view, of all the historical writings of antiquity; and hence Folard could not possibly have made a better choice. But not being acquainted with Greek, he was obliged to entrust the translation to Dom Thuillier, whilst he simultaneously laboured at his commentaries, which he placed in the form of notes at the end of each chapter of Polybius. These commentaries are of an unexampled prolixity, and the style frequently descends to triviality; in the same page things the most incoherent are often jumbled together; and he makes continual efforts to connect everything with his system of columns and deep formations. But however imperfect the work of Folard may be considered in a literary point of view, military men will find it in many respects eminently useful; for, besides judicious remarks and learned researches respecting the wars of the ancients, we meet with much valuable information, which we cannot help regretting that the historians of this period should not have oftener referred to. He explains the causes and the results of these events with a frankness which was often hurtful to himself, but which will always be useful to posterity. This frankness, indeed, which had raised up so many obstacles to his advancement whilst he had arms in his hands, also created opposition to his projects after he became author. When he had reached the sixth volume of his Polybius he was ordered to refrain from indulging in the same sort of discussions as in the preceding portion of the work. Of this injunction he complains bitterly in the preface to the volume in question, and says that he has been restrained precisely at the place where his author became more interesting, and where he felt himself inspired by events more worthy of remark and annotation.

Folard has prefixed to this immense work his *Treatise on Columns*, and the deep order, which he regards as the basis of all good tactics. His opinion in favour of deep formations encountered much opposition at the time when it was first promulgated, and the controversy which it then occasioned has not yet been altogether set to rest. The most judicious of his critics was General Savornin, a Swiss officer in the service of Holland, who published anonymously *Les Sentiments d'un Homme de Guerre sur le nouveau Système de Folard*. Of all his adversaries this author is the one whom he treats with the greatest respect in the prefaces to his volumes, which, as is well known, he converted into a sort of field of battle, where he attacked *à outrance* those who had ventured to dispute his opinions. But the best part of the commentaries on Polybius is undoubtedly that where Folard treats of the tactics of the ancients, and particularly of their manner of attacking and defending strong places. This is a subject which he had maturely considered, with reference to the instruments of war in use amongst the ancients. He had even caused to be constructed a catapult, the experiments made with which transported him with admiration; and he did not hesitate to affirm, that if it were possible for him, with the machines and means of the ancients, to attack a place defended by the artillery of the moderns, he would make sure of taking it in a very short time. Such an assertion, it may very easily be imagined, was much better calculated to astonish than convince. His ideas on strategics were scarcely, if at all, less extraordinary; and his system of columns and deep formations will be sufficiently appreciated if we consider that, in the numerous wars which have occurred since its publication, there is no sovereign nor general who has deigned to put it fully in practice. It must be admitted, however, that attacks in close columns, which have been so generally and so successfully employed in our time, are in some sort an imitation of Folard's system. This method no doubt proves that the deep order is sometimes the best; but attacks in close columns, by platoons, divisions, or battalions, such as have latterly been practised, present advantages which Folard had never dreamed of, namely, the power of deploying if necessary, of changing the front and direction of the mass with extreme facility, and of passing rapidly from the deep to the extended, and from the extended to the deep formation.[1] Folard, if we may be allowed the expression, was so deeply infected with his system and his discoveries, that he saw everywhere the deep order and columns of attack. He had read little of the Bible; but happening one day to take up that sacred book, he exclaimed, on reading the first page, "Do you know that Moses must have been a great captain. He has discovered my column."

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[1] "In general the formations of a good military nation are extended, whilst those of a bad one are deep." So says Count von Bismark (*Tactics of Cavalry*, p. 200, Engl. transl.); and the remark is undoubtedly well founded. At the same time, the diminution of depth in the formation of modern armies has been a natural consequence of the constantly augmenting power of artillery and of small arms. In ancient times battles were generally decided by bodily strength; and as armies had then no concentric fire to apprehend, they could with safety assume that deep formation which was calculated to overwhelm the enemy by impulsion alone. But the invention of gunpowder, and the destructive effects of cannon fire, arising from the improvement of artillery, necessitated in modern times a departure from the dense formations of antiquity. This was strongly felt by Gustavus Adolphus, who, whilst his opponents, Tilly and Wallenstein, formed their infantry in solid masses, drew up his men six deep, and, in this extended formation, overwhelmed the columns of his adversaries. If we may judge from recent examples, however, deep formations are not even now so inappropriate as may be imagined; and, absurd as the columns of Folard may appear, it was by the employment of analogous masses, directed with a celerity which at once increased their momentum and diminished the ravages of cannon fire, that Napoleon proved so often successful. In the order of battle laid down by Jomini as combining in the greatest degree mobility with solidity, the corps destined for the attack are arranged in two lines of battalions, each battalion being formed in column of grand divisions. "La troupe d'attaque," says he, "aussi bien que la réserve, ne sauraient être mieux disposées qu'en colonnes d'attaque par la centre; car la réserve, devant être prête à tomber sur l'ennemi au moment décisif, doit la faire avec force et vivacité, c'est-à-dire, en colonnes." (*Traité des Grandes Opérations Militaires*, tom. iii. c. 35, p. 357.) The Duke of Wellington, it is true, generally attacked with deployed lines; but these, it is to be observed, were sometimes of deep formation. The body of English guards which so successfully attacked the columns of the imperial guard at the close of the battle of Waterloo was formed four deep; and the final charge *en muraille* executed by the British line on that day was also made in the same formation. It is to be observed, however, that the columns of the imperial guard were torn up and shattered by a close concentric fire of artillery, before the English guards advanced to the attack. To this indeed columnar formations are always more or less exposed; for though the evil may be lessened by celerity of movement, it cannot be avoided, and a rapid advance is always of itself productive of some confusion and disorder. Hence the attack in column has by no means been attended with the results which the Chevalier Folard expected from it. The Duke of Wellington always deployed before battle, and at Waterloo defeated an army drawn up in columns of attack, this being one of the few instances where his lines exceeded the usual formation of two deep. The French lost the battle of Essling by attacking the centre of the Austrian line in column. Massena's columns failed at Busaco; Victor's were baffled at Barossa; and even the Spaniards broke two columns of the French army at St Marcial. At Waterloo, again, the repeated advances of Napoleon's columns proved unavailing against the linear formation of the British; and although at the close of the day the chosen columns of the imperial guard advanced with a determined bravery which would have done honour to the troops of any nation, they had no better success. These facts naturally shake our faith in columns, and serve to confirm the remark of Bismark, that the formations of the best military nations are not deep, but extended. An undisciplined multitude suddenly drawn together, or an army possessing little moral force, may be appalled by the imposing appearance of

Count Saxe, who had known Folard in Sweden, appears to have attached much importance to his opinions. The esteem which that able commander entertained for him may be judged of from his letters, some of which are subjoined to the work entitled *Mémoires pour servir à l'Histoire de M. le Chevalier de Folard*, Paris, 1753. Folard was a good engineer, and excelled both in drawing and in the construction of military plans. It was from designs by him that the Abbé Gédoyn was enabled to give the plans of the different battles in his translation of Pausanias. Folard has been denominated the French Vegetius; but he himself would not have been much flattered by this title, as he often speaks with contempt of Vegetius. As he cites a great number of ancient authors, he has often rectified their text, which had been altered by the copyists; and he has also sometimes indicated mistakes in the translations of their works. The publication of his Polybius procured him a great reputation in Europe, and was soon followed by his admission into the Royal Society of London. The king of Prussia, Frederick the Great, having desired to make trial of his system, the chevalier was invited to repair to Berlin, to be a witness of the experiment; but his advanced age prevented him from undertaking so long a journey. Nevertheless this warlike monarch attached but little importance to the writings of Folard, which he has even treated as visionary and extravagant in several passages of his correspondence, and particularly in the volume which he caused to be printed in 1761, under the title of *L'Esprit du Chevalier de Folard*, in 8vo. In the preface to this compilation, Frederick says, "Il (Folard) avait enfoui des diamants, au milieu du fumier; nous les avons retirés. On a fait main basse sur le système des colonnes: on n'a conservé que les manœuvres de guerre, dont il donne une description juste; la critique sage qu'il emploie sur la conduite de quelques généraux Français, certaines règles de tactique, des exemples de defenses singulières et ingénieuses, et quelques projets qui fournissent matière à des réflexions plus utiles encores que ces projets mêmes." Such was the opinion of the greatest captain of his time respecting the writings of Folard. The literary labours of this tactician impaired his health more rapidly than the fatigues of war, which, indeed, appear to have made little or no impression on his constitution. Wishing once more to visit his native city, Folard repaired to Avignon in 1750, and died there on the 23d of March 1752, at the advanced age of eighty-three.

This able warrior failed to attain the first rank in the army, though he had eagerly aspired to it; nevertheless he was content with his lot; and with a small patrimony, and some pensions which had been granted him by the king, he found means to do good. His last years would have been perfectly happy if he had not recklessly disturbed their serenity by throwing himself *à corps perdu* into an imprudent controversy, where, from his great irascibility and excessive self-love, he often furnished arms against himself. Another circumstance also served to embitter his declining days. Having allowed himself to be drawn into the party of the Appellants, as they were called, he was represented by the pamphleteers of the time as one of those who had given themselves up to visionary convulsions upon the tomb of Deacon Pâris. The new sect was of course delighted to be able to refer to such evidence in support of its absurd pretensions; and it is easy to conceive the ridicule which this must have drawn down on the old chevalier. The Cardinal de Fleury was in fact so much displeased with him that he ordered Folard to quit Paris; and it was only at the earnest entreaty of several generals, who bore testimony to his numerous and important services, that this order was recalled. During his whole life Folard had enjoyed the most robust health. But a single infirmity afflicted him from his youth, and increased with his age; we mean, a natural deafness, which had often nearly proved fatal to him in the field of battle. In his old age he was almost entirely destitute of the sense of hearing.

Folard's military opinions, which had excited so much discussion during his lifetime, occasioned a great deal more long after his death. His system of columns, warmly attacked in the *Mémoires Militaires* of Colonel Guischardt in 1758, and also in the *Mémoires Critiques* of the same author in 1774, was defended with much heat in the *Recherches d'Antiquités Militaires* of the Chevalier de Lalooz, Paris, 1770, and likewise in another volume published by the same author in 1776, under the title of *Defense du Chevalier Folard*. The history of Polybius, with the commentaries, was first printed at Paris in six vols. 4to, 1727–1730, and next at Amsterdam, 1753, in seven vols. 4to. The seventh volume, which is a supplement, is not found in the Paris edition. It contains, 1. *Les Nouvelles Découvertes sur la Guerre;* 2. *Lettre Critique d'un Officier Hollandais* (Terson); 3. *Sentiments d'un Homme de Guerre* (Savornin) *sur le Système Militaire du Chevalier de Folard;* 4. Answer of Folard to his critics. The commentaries on Polybius have been abridged and printed separately by Chabot, Paris, 1757, in three vols. 4to. There are two German translations, one printed at Berlin, and the other at Vienna. The observations on the battle of Zama, and on the history of Epaminondas, which had been published separately in 1738 and 1739, form part of the commentaries on Polybius; and, as already stated, the author has also combined with these commentaries his *Traité de la Colonne*, as well as that on the attack and defence

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a column advancing to the attack, and give way from apprehension; but no such effect can be produced where courage and discipline are found united. This was signally exemplified at Albuera, where, in the attack on the key of the position, the French columns, though momentarily successful, found it impossible to deploy, under the incessant and dreadful vollies, which swept away the head of every formation, and, after a desperate and unavailing struggle, were driven headlong down the ascent. Every order is good against troops who do not defend themselves; in that case it is only necessary to march. But against troops who do defend themselves, and who to natural courage unite that discipline which teaches them to preserve unshaken the stability of their order, the attack in column will seldom prevail, unless combined with extended formations. As much, however, may be said on both sides, many writers have been led to maintain extreme opinions on the subject, as the following passage, extracted from a very ingenious essay on tactics, will abundantly testify. "The victories gained by the natural gallantry and intelligence of the French soldiers, in spite of the system under which they were supposed to fight, gave military opinion a bias in favour of masses and solid formations, simply disgraceful to human understanding, at a time when hundreds of pieces of artillery already frowned destruction over every field of battle. Nothing but the most profound ignorance of every principle of professional science, as well as the most callous indifference to the lives and sufferings of men, could for a moment have tolerated a system that tended to eradicate from the heart every feeling of humanity, and to stifle military genius in the bud. It was well calculated for ignorant, grasping, and ambitious leaders; it enabled such men, in the absence of military talents, to gain battles by quenching with the blood of their own soldiers the fires of the enemy, and literally to overwhelm the foe with the mangled bodies of the human victims so lavishly placed at their disposal by ruthless ukases and conscriptions." (Mitchell's *Essay on Tactics*, part iv. United Service Journal, July, 1834.)

of strong places. Folard is likewise the author of a tract, entitled *Fonctions et Devoirs d'un Officier de Cavalerie*, Paris, 1733, in 12mo. (A.)

FOLCLANDS, or Folklands. Copyhold lands were so called in the time of the Saxons, as charter lands were called *boclands*. *Folkland* was *terra vulgi* or *terra popularis*, the land of the common people, who had no certain estate therein, but held it under the rents and services accustomed or agreed, at the will only of their lord the thane; and it was therefore not put in writing, but accounted *prædium rusticum et ignobile*.

FOLCMOTE, or Folkmote (Saxon, *Folcgemote*, that is, *conventus populi*), is composed of *folk*, *populus*, and *mote* or *gemote*, *convenire*, and originally signified a general assembly of the people called together to consider of and order matters of the commonwealth. According to Spelman, the *folcmote* was a sort of annual parliament or convention of the bishops, thanes, aldermen, and freemen, which assembled upon every May-day, and in which the laymen were sworn to defend one another and the king, and to preserve the laws of the kingdom, after which they consulted of the common safety. But, from the laws of the Saxon kings of England, Dr Brady infers that it was an inferior court, held before the king's *reeve* or steward every month, to do *folk* right, or compose smaller differences; and that from it there lay an appeal to the superior courts. (*Gloss.* p. 48.) Squire seems to think that the *folkmote* was not essentially distinct from the *shiremote*, or common general meeting of the county. (See his *Angl. Sax. Gov.* 155, n.) Manwood mentions *folcmote* as a court holden in London, in which all the *folk* and people of the city did complain of the mayor and aldermen for misgovernment within the said city; and this word is still in use, denoting *celebrem ex tota civitate conventum.* According to Kennet, the *folcmote* was a common council of all the inhabitants of a city, town, or borough, convened by sound of bell, or otherwise, to the *Mote Hall* or *House;* or it was applied to a larger congress of the freemen within a county, called the *shiremote*, where formerly all knights and military tenants did homage to the king, and elected the annual sheriff on the first of October, until 1315, when, to avoid tumults and riots, this popular form of election was, by 3 Edward I. merged in nomination by the king. After this time the city *folkmote* was swallowed up in a select committee or common council, and the county *folkmote* in the sheriff's tourn and assizes.

The word *folkmote* was also used to signify any kind of popular or public meetings, as those of the tenants at the *court leet* or *court baron*, in which signification it was of a less extent than that above explained. (*Paroch. Antiq.* 120.)

FOLENGO, Theophilus, better known by his assumed name of *Merlin Cocaio*, an eccentric genius, and burlesque poet, was descended of a noble family of Mantua, and born at a place called Cipada, beyond the suburb of St George on the lower lake, in the year 1491.[1] From his infancy he showed great quickness and vivacity of mind, a decided taste for poetry, and a singular facility of turning everything which occurred into verse. According to Tomasini and others, he completed his studies at Bologna, and at the age of sixteen entered the order of Benedictines of the congregation of Monte Cassino, near Brescia, where his elder brother had taken the vows about three months before. He then assumed the name of Theophilus instead of Jerome, which was his baptismal name, and eighteen months afterwards he made profession as Benedictine. At first his life was regular; but a new superior of the monastery of Brescia, where he had become professed, having permitted or introduced great disorders there, Folengo, led away by bad example, forgot his vows, and ended by quitting the monastery and his habit together, to stroll about with a pretty woman who had captivated his fancy. This young person, who is said to have been well born, is not directly mentioned by him in his works; but as he has put the letters of her name to a species of canzone or ode, consisting of thirteen verses, we thence collect that she was called Girolama Dieda. With this female he wandered about for ten years, having, as appears, no other resource for procuring a livelihood than his talents and his verses. He had commenced a poem in Latin, which, as far as it went, displayed much elegance; but he soon quitted serious poetry, in which he could at most only hope to obtain a secondary rank, for a kind which he called Macaronic, and in which he conceived himself qualified to occupy the first place. The basis of the language employed by him is Latin, mixed with Italian words, and still more with the Mantuan patois, which was his mother tongue, and to which he gave Latin terminations. In his poem he recounts the ridiculous adventures of a hero called Baldus, among which are several which had happened to himself; and under the mask of burlesque and buffoonery may be found thoughts and maxims instinct with good sense, not to mention original and piquant touches of satire on the conduct of the great, the vanity of titles, and the different pursuits of men. It has been alleged that he gave the name of Macaronic to this strange species of composition, in which Latin is intermixed with Italian and Mantuan, because macaroni is seasoned with a mixture of flour, butter, and cheese; and in fact, to a mind like his, this fanciful and grotesque resemblance was sufficient. Instead of dividing his poem into books or cantos, he accordingly divided it into macaronis (*macaronea prima*, *macaronea secunda*, etc.), of which there were seventeen in the first edition and twenty-five in the subsequent ones; and he published the whole under the name of *Merlinus Cocajus*, which afterwards became famous. In a few years several editions were published; but the success of these facetious productions did not prevent their being bitterly criticised. The author was severely censured, both for the style in which he wrote, and the license of ideas and expressions in which he indulged; a circumstance which irritated him so much that, changing his style, or rather language and name, he composed in three months a satirical Italian poem, in eight cantos, on the infancy of Roland, to which he gave the title of *Orlandino*, and affixed the name of *Limerno Pitocco;* *Limerno* being the anagram of *Merlino*, and *Pitocco* or mendicant being significative of the state to which he was occasionally reduced. He had nevertheless made many friends in the world by the reputation which he had acquired, the extent of his knowledge, and the agreeable qualities of his mind; and he had even retained some in the cloister, into which, when tired of a wandering and miserable life, he was received back with open arms. He signalized his return by a work on the subject of his conversion, entitled *Il Chaos del Triperuno*, or The Chaos of Three for One, meaning himself, who had been successively Theophilus Folengo, Merlin Cocaio, and Limerno

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[1] Folengo, in his verses, has several times mentioned the place of his birth in his own peculiar vein:

> Magna suo veniat Merlino parva Cipada.—
> Mantua Virgilio gaudet, Verona Catullo,
> Dante suo florens urbs Tusca, Cipada Cocajo.—
> Nec Merlinus ego, laus, gloria, fama Cipadæ, etc.

Pitocco. The work is a medley of verses, songs, and narrations, in Latin, Italian, and the Macaronic dialect, in short, a veritable chaos, divided into three parts, called, after Statius, *Sylvæ*. He then applied himself to correct his other works, and the *Orlandino* appeared in seven cantos instead of eight, with corrections and considerable suppressions, especially in the seventh canto. He also undertook to chasten the Macaronics; and having completed this labour, he entrusted the publication of the purified edition to his brother Francisco Folengo. But although these two works were thus rendered less exceptionable and more orthodox, the corrected editions have fallen into oblivion. Folengo appears to have remained during several years at Capri, a country-house belonging to his order, between Brescia and Bergamo, and, in fact, to have divided his time between this retreat and Brescia till 1536 or 1537, in one or other of which years he composed his Italian poem on the Humanity of the Son of God, the most orthodox of all his works, and which would be the most edifying if one could really be edified by that which is unreadable. He was then sent into Sicily to the monastery of St Martin *delle Scale*, where he appears to have remained till 1543, when he returned into Italy, and retired to the convent of the Holy Cross of Campesa, near Bassano, on the banks of the Brenta, where he died in little more than a year afterwards, 9th December 1544, in the fifty-third year of his age. The following is a list of his works: 1. *Merlini Cocaji Poëtæ Mantuani Macaronices* libri xvii. Venice, 1517, in 8vo; 2. *Orlandino, per Limerno Pitocco da Mantova composto*, Venice, 1526, in 8vo; 3. *Chaos del Triperuno, con privilegio*, Venice, 1527, in 8vo; 4. *La Humanità del Figliuolo di Dio, in ottava rima, per Theophilo Folengo Mantovano*, Venice, 1533, in 8vo; 5. *Joannis Bapt. Chrysogoni Folengii Mantuani anchoretæ dialogi quos Pomiliones vocat*, 1533, in 8vo; 6. Several *Poems*, the greater part on subjects of devotion, and some also in the Macaronic vein, which have not been printed. (A.)

FOLIATING OF LOOKING-GLASSES, the spreading the plates over with quicksilver, after they have been polished, in order to reflect the image. The mode in which it is performed may be shortly described. A thin blotting paper is spread on the table, and sprinkled with fine chalk, and a fine lamina or leaf of tin, called *foil*, is laid over it; upon this is poured mercury, which is to be distributed equally over the leaf; a clean paper is then laid upon the mercury, and over that the glass plate, which is pressed down with the right hand, and the paper gently drawn out with the left. This being done, the plate is covered with a thicker paper, and loaded with a greater weight, that the superfluous mercury may be driven out, and the tin adhere more closely to the glass; and when it is dried, the weight is removed, and the looking-glass complete.

FOLIGNO, a city of the delegation Perugia, in the papal dominion, in Italy. It is situated in a rich and fertile plain, near the river Topino, whence it receives the waters of the Maroggia. It contains eight churches, twelve monasteries, eight nunneries, and a magnificent state-house, in which is a museum of antiquities. The inhabitants, amounting to 15,102, are employed in bleaching wax and making tapers, in woollen manufactures, in making paper, and various conserves. Long. 12. 35. 40. E. Lat. 45. 6. 46. N.

FOLIO, among printers and booksellers, the largest form of books, when each sheet is so printed that it may be bound up in two leaves only.

FOLKES, MARTIN, a philosopher and antiquary of considerable eminence, was born at Westminster, in the year 1690. A Mr Cappel, once professor of Hebrew at Saumur, was his private tutor. When about seventeen years of age he was sent to Clare-hall, Cambridge, where he applied himself to the study of philosophy and the mathematics; and when only twenty-three years of age he was chosen a fellow of the Royal Society. His ingenious communications acquired him so much applause that he was frequently chosen into its council. He was in habits of friendship with the illustrious Newton, at that time president; and by his influence was elected one of the vice-presidents in the year 1723. Mr Folkes became a candidate for the chair on the death of Sir Isaac Newton; but the superior interest of Sir Hans Sloane rendered his application ineffectual. In 1733, and the two subsequent years, he resided for the most part in Italy, with the view of improving himself in the knowledge of classical antiquity. To ascertain the weight and value of ancient coins, he carefully consulted the cabinets of the curious; and on his return home he presented to the Antiquarian Society, of which he was a member, a dissertation on the subject. He read before the same learned body a dissertation on the measurement of Trajan's and Antoninus' pillars, together with other remains of antiquity. The fruits of his observations he presented to the Royal Society, particularly *Remarks on the Standard Measure preserved in the Capitol of Rome*, and the model of an ancient globe in the Farnese palace. He visited Paris in 1739, where he was received with great respect, and admitted into the society of the most distinguished literary characters of that metropolis. This respect indeed he was entitled to by his unwearied application to many branches of knowledge alike curious and useful. His valuable work upon English Silver Coins was printed in the year 1745. Amongst the many honours conferred upon Mr Folkes, was that of being created doctor of laws by both universities, and chosen president of the Antiquarian Society. He continued to furnish the Philosophical Transactions with many learned papers, till his career was cut short by a paralytic stroke, which terminated his useful life in the year 1654. He was a man of extensive knowledge and approved accuracy; but the chief benefit to science which resulted from his labours was his treatise on the intricate subject of coins, weights, and measures. His cabinet and library, which were large and valuable, were exposed to public sale after his death. His private character was distinguished for politeness, generosity, and friendship.

FOLKINGHAM, a market-town of the county of Lincoln, in the hundred of Aveland and Kesteven, 107 miles from London. It is beautifully situated on the ascent of a hill, which affords a fine prospect over the plains below it. The church has a lofty tower, which is visible at a great distance. A county jail has been recently erected, and the quarter-sessions for the county are held here. The market is held on Thursday. The population amounted in 1801 to 531, in 1811 to 659, in 1821 to 759, and in 1831 to 744.

FOLKSTONE, a market-town of the county of Kent, on the sea-shore, in the hundred of its own name, of the lathe of Shepway, seventy-two miles from London. It is a member of the Cinque Ports under Dover, but returns no members to parliament. It is built on the ascent of a steep hill, the foot of which forms the sea beach. The chief employments are fishing, and the contraband trade in articles charged with heavy duties. The market is held on Thursday, and well supplied. The population amounted in 1801 to 3257, in 1811 to 3697, in 1821 to 4541, and in 1831 to 4296.

FOLKLAND, and FOLKMOTE. See FOLCLANDS and FOLCMOTE.

FOLLICULUS (from *follis*, a bag), a species of seed-vessel, first mentioned by Linnæus in his *Delineatio Plantarum*. It generally consists of one valve, which opens from bottom to top on one side, and has no suture for fastening or attaching the seeds within it.

FOLLICULI are likewise defined by the same author to be small glandular vessels distended with air, which appear on the surface of some plants, as at the foot of water-milfoil, and on the leaves of aldrovanda. In the former the leaves in question are roundish, and furnished with an appearance like two horns; in the latter, pot-shaped and semicircular.

FOLLIS anciently signified a little bag or purse, and hence it came to be used for a sum of money; nay, different sums were called by the same name. Thus the scholiast on the Basilics mentions a *follis* of copper which was worth but the twenty-fourth part of the *miliarensis*; the *glossæ nomicæ*, quoted by Gronovius and others, were, one of 125 *miliarenses*, and another of 250 denarii, which was the ancient *sestertium*; and three different sums of eight, four, and two pounds of gold were each called *follis*. According to the account of the scholiast, the ounce of silver, which contained five *miliarenses* of sixty to the pound, was worth 120 *folles* of copper. The glossographer, describing a *follis* of 250 denarii, says it was equal to 312 pounds six ounces of copper; and as the denarius of that age was the eighth part of an ounce, an ounce of silver must have been worth 120 ounces of copper; therefore the scholiast's *follis* was an ounce of copper, and equal to the glossographer's *nummus*. But as Constantine's copper money weighed a quarter of a Roman ounce, the scholiast's *follis* and the glossographer's *nummus* contained four of them, as the ancient *nummus* contained four *asses*.

FOMAHAUT, in *Astronomy*, a star of the first magnitude, in the constellation AQUARIUS.

FOMENTATION, in *Medicine*, is a fluid externally applied, usually as warm as the patient can bear it. The degree of heat should never exceed that of producing a pleasant sensation; great heat produces effects very different from those intended by the use of fomentation.

FONG-HOA-TCHING, a large, populous, and commercial town of Chinese Tartary, on the borders of Corea. It has manufactures of white and transparent paper, fabricated from cotton, which is used in windows instead of glass. Long. 143. 42. E. Lat. 40. 31. N.

FONG-TCHING, a town of China, of the third rank, in the province of Pe-tche-li. It is situated on the banks of the Grand Canal, in a fine and fertile country, and is said to be rather in a state of decay. It is twelve miles north of Kiang.

FONG-YANG, a city of China, of the first rank, in the province of Kiang-nang. It is situated on a mountain, near the Yellow River; and being the birth-place of one of the Chinese emperors, he resolved to embellish the city, and render it the seat of government. But he afterwards transferred the seat of government to Nanking, and the few works which had been completed were abandoned. This city comprehends eighteen towns under its jurisdiction. It is 340 miles south of Pekin. Long. 117. E. Lat. 32. 52. N.

FONT, among ecclesiastical writers, a large basin, in which water is kept for baptizing infants or other persons.

FONT, in the art of printing, denotes a complete assortment of letters, accents, &c. used in printing. See FOUNT.

FONTAINE, JEAN DE LA, a celebrated French poet, was born at Château-Thierry, in Champagne, on the 8th of July 1621. At the age of nineteen he entered into the congregation of the Oratory, but quitted it about eighteen months afterwards. He was twenty-two years of age before he knew his own talents for poetry; but hearing read an ode of Malherbe, upon the assassination of Henri IV., he was so seized with admiration of it, that the poetical fire, which had before lain dormant within him, seemed to be kindled from that of the other great poet. La Fontaine therefore applied himself to read, to meditate, to repeat, in fine to imitate, the works of Malherbe. The first essays of his pen he confined to one of his relations, who made him read the best Latin authors, and then the best compositions in French and Italian. He applied himself likewise to the study of the Greek authors, particularly Plato and Plutarch. Some time afterwards his parents induced him to marry a daughter of a lieutenant-general, a relation of the great Racine. This young lady, besides possessing great beauty, was remarkable for the delicacy of her wit, and La Fontaine never composed any work without consulting her. But as her temper was none of the best, the poet, to avoid dissension, separated himself from her company as often as he well could. The celebrated Duchess of Bouillon, niece of Cardinal Mazarin, being exiled to Château-Thierry, took particular notice of La Fontaine; and on her recal he followed her to Paris, where, by the interest of one of his relations, a pension was settled upon him. He met with friends and protectors amongst the most distinguished persons of the court, but Madame de la Sablière was the most prominent. She took him to live at her house; and there Fontaine, divested of domestic concerns, led a life conformable to his disposition, and cultivated an acquaintance with all the great men of the age. It was his custom, after he had fixed at Paris, to go every year, during the month of September, to his native place of Château-Thierry, and pay a visit to his wife, carrying with him Racine, Despréaux, Chapelle, or some other celebrated writers. After the death of Madame de la Sablière, he was invited into England, particularly by Madame Mazarin, and by St Evremond, who promised to secure him all the comforts of life; but the difficulty of learning the English language, and the liberality of the Duke of Burgundy, prevented his crossing the Channel.

About the end of the year 1692 he fell dangerously ill, and, as is customary upon these occasions in the Catholic church, he made a general confession of his whole life to Father Poguet of the Oratory; and, before he received the sacrament, he sent for the gentlemen of the French Academy, and in their presence declared his sincere compunction for having composed his *Tales*, a work he could not reflect upon without the greatest repentance and detestation; promising that if it should please God to restore him to health, he would employ his talents only in writing upon matters of morality or piety. He survived this illness two years, living in the most exemplary and edifying manner, and died on the 13th of March 1695, at the age of seventy-four. When his body was stripped they found next his skin a hair shirt, which gave room for the following expression of the younger Racine:

> Et l'auteur de *Jaconde* est orné d'un cilice.

La Fontaine has been justly regarded as the prince of fabulists. In his hands the apologue, which had hitherto been extremely confined, became a little poem, in which all the shades, varieties, and qualities of the other kinds of poetry were intermingled with inimitable art and simplicity. Epic poetry there recognised its recitals and its characters; dramatic poetry its actors, dialogues, and passions; didactic poetry its lessons and instruction. We there find simplicity united with vigour and dignity, and great naiveté with exquisite wit and refinement. Nothing can exceed the freshness and grace with which he paints gentle, amiable, and smiling objects; whilst, besides the other charms of the picture, the reader is agreeably surprised by those strokes of genuine comic humour in which he so greatly excelled. There is no doubt much art in all this; and it is indubitable that La Fontaine carefully elaborated his fables; but as the perfection of art is to conceal it, and simplicity is the joint result of genius and labour, so, by the union of these eminent qualities, La Fontaine, without having almost invented any thing, is nevertheless regarded as one of the most original of the French poets. He invented nothing, said Laharpe, but his style; and the secret remained with him. In imitating others he became inimitable; and he is perhaps the only poet of whom this may with truth be said. For the numerous editions of his works we must refer our readers to Brunet's *Manuel du Libraire*. The best edition of the *Fables de La Fontaine* is that of Charles Nodier, with a new literary and grammatical Commentary, Paris, 1818, in 2 vols. 8vo. Of the *Œuvres Complètes de La Fontaine* there are only four editions, all of which were published at Paris in 1813, 1814, 1817, and 1818 respectively. These editions alone contain the ballad commencing with the verse

> C'est à bon droit que l'on condamne à Rome,

and *Ragotin*, a metrical comedy, in five acts, discovered by Barbier in 1811. (See *Histoire de la Vie et des Ouvrages de M. de La Fontaine*, 1811.)

FONTAINES, Pierre-Francois Gyot Des, a French critic, the son of a councillor in the parliament of Rouen, was born in that city on the 18th December 1685, and terminated his career at Paris on the 16th December 1745. At the age of fifteen he entered into the society of the Jesuits, where he received orders; and at thirty quitted it to return to the world. He was a priest, and had a cure in Normandy, which he soon left, and, as a man of wit and letters, lived for a time with the Cardinal d'Auvergne. Having excited some attention at Paris by certain critical productions, Desfontaines was, in 1724, employed to conduct the *Journal des Sçavans.* He acquitted himself well in this department, and was peaceably enjoying the applause of the public, when his enemies, exasperated by critical strictures in his journal, caused him to be accused of an abominable crime, and procured his imprisonment. By the credit of powerful friends, however, he was set at liberty in fifteen days: the magistrate of the police took upon himself the trouble of justifying him, in a letter addressed to the Abbé Bignon; and this letter having been read amidst his fellow-labourers in the journal, he was unanimously re-established in his former credit. This happened in 1725. But with whatever reputation he acquitted himself in conducting his journal, frequent disgusts induced him at length to abandon it. Meanwhile he laboured in some new periodical works, from which he derived his greatest fame. In 1731 he commenced one under the title of *Le Nouvelliste du Parnasse, ou Refléxions sur les Ouvrages Nouveaux;* but it only extended to two volumes, the work having been suppressed by authority, from the incessant complaints of the authors ridiculed therein. About three years after, in 1735, he obtained a new privilege for a periodical production entitled *Observations sur les Ecrits Modernes*, which, after extending to thirty-three volumes, was suppressed in 1743. Yet the year following, 1744, he published another weekly paper called *Jugemens sur les Ecrits Nouveaux*, which proceeded to eleven volumes; the last two having been executed by other hands. In 1745 he was attacked with a disorder in the chest, which ended in a dropsy that proved fatal in five weeks. "He was born a sentimental person," says Fréron; "a philosopher in conduct as well as in principle; exempt from ambition; and of a noble, firm spirit, which would not submit to sue for preferments or titles. In common conversation he appeared only a common man; but when subjects of literature, or any thing out of the ordinary way, were agitated, he discovered great force of imagination and wit."

FONTANA, Felix, a distinguished physiologist and experimental philosopher, was born at Pomarolo, a little town in the Tyrol, on the 15th April 1730.

He began his studies at the neighbouring city of Roveredo, and continued them in the schools of Verona and Parma, and afterwards in the universities of Padua and Bologna. He then visited Rome, and went to Florence, where he obtained from the Emperor Francis I. who was at that time Grand Duke of Tuscany, the appointment of professor of philosophy at Pisa; but the Grand Duke Peter Leopold, who was also afterwards emperor, invited him to settle at Florence, and gave him an establishment connected with his household, as *Fisico* or naturalist, and as director of the cabinet of natural history, which was afterwards rendered by his exertions one of the principal ornaments of the city of Florence.

Fontana became the author of many well-known works on physiology, natural philosophy, and chemistry. In 1757 he was engaged in an investigation tending to confirm the doctrines of Haller respecting the irritability of the muscles, considered as a distinct quality inherent in those organs. Haller has published several of his letters as a part of his own *Mémoires sur les parties sensibles et irritables;* and the subject afforded Fontana the materials of several successive essays. 1. *De Irritabilitatis legibus nunc primum sancitis,* Atti di Sienna, vol. iii. p. 209, 1767. 2. *Ricerche filosofiche sopra la Fisica animale*, 4. Flor. 1775. This volume contains only the *Essay on the Laws of Irritability*, stating, first, the general outline of the doctrine, then entering into the different intensity of the property of irritability, and its loss by exhaustion or by inactivity, and discussing the action of the heart, and the peculiarities of the death occasioned by electricity. 3. Another link of the same chain of investigation is found in the earlier publication *De' moti dell' iride*, 8. Lucca, 1765; showing that the contraction of the pupil depends on the effect of light falling on the retina, and not on the iris itself, and establishing an analogy between the motions of the uvea, and the semi-voluntary actions of the muscles of respiration. 4. One of the most important of Fontana's works is his *Ricerche fisiche sopra 'l veneno della vipera*, Lucca, 1767; containing an immense multitude of experiments calculated to show that the poison of the viper acts by mixing with the blood, and destroying the irritability of the muscles to which it is conveyed; but that the bite of the European viper, though fatal to small animals, is scarcely ever capable of producing any immediately dangerous effects on the human frame. 5. The same matter was republished, with many additions, in the *Traité sur le Vénin de la Vipère, sur les Poisons Américains, sur le Laurier-cérise, et sur quelques autres Poisons*, Berlin, 1787; together with some observations on the primitive structure of the animal body, experiments on the reproduction of the nerves, and remarks on the anatomy of the eye. 6. In 1766 our author published an essay entitled *Nuove Osservazioni sopra i globetti rossi del sangue*, Lucca; confuting the assertions which had lately been advanced by Della Torre, respecting the complicated structure and changes of form of the globules of the blood. 7. In the next year appeared *Osservazioni sopra la ruggine del grano*, Lucca, 1767; describing an animalcule like an eel, to which he attributes the rust of coin, but which has not always been found by subsequent observers in similar cases, perhaps for want of accurate distinction. 8. There is also a *Lettre sur l'Ergot, Journ. Phys.* vii. p. 42. 9. The *Lettera sopra le Idiutidi e le Tenie, Opuscoli Scelti*. vi. p. 108, Milan, 1783, contains an account of the hydatids which produce the symptoms of vertigo in sheep. 10. A *Lettre à M.* * * *, *Journ. Phys.* vii. p. 285, contains some remarks on the circulation of the sap in plants. 11. In an essay *Sur le Tremella, Journ. Phys.* vii. p. 47, a zoophyte of a green colour, described by Adanson and others as a plant, is shown to consist of a multitude of little animals in continual motion.

12. Mr Fontana entered also very minutely, but with

more industry than accuracy or closeness of reasoning, into the chemical novelties which occupied so much attention throughout Europe in the latter half of the last century. He seems, however, to have had the merit of first applying the discoveries of Priestley respecting the effects of the nitric oxide to the examination of the qualities of the atmosphere by means of the eudiometer, which is the subject of his *Descrizione e usi di alcuni Stromenti per misurar la salubrità dell' aria*, 8. Flor. 1774, 4to, 1775, and is further illustrated in his (13.) *Recherches physiques sur la nature de l'air dephlogistiqué et de l'air nitreux*, 8. Par. 1776. He also observed the remarkable property that charcoal possesses of absorbing several times its bulk of different gases. 14. In the *Ricerche fisiche sopra l'aria fissa*, 4. Flor. 1775, he is by no means equally fortunate, having fancied that the acidity of the fixed air is not essential to it, but accidentally derived from the stronger acid employed in expelling it from the earth or alkali. 15. The *Philosophical Transactions for* 1779, p. 187, contain his *Experiments and Observations on the Inflammable Air breathed by various Animals*, consisting of a repetition of Scheele's attempt to breathe hydrogen gas, which did not always create a sensation of immediate uneasiness, though it was sometimes productive of alarming consequences. 16. In the same volume, p. 432, we find an interesting *Account of the Airs extracted from different kinds of Waters, with thoughts on the Salubrity of the Air at different places*, showing that the air afforded by water is very different under different circumstances, but that the quality of the atmosphere itself scarcely ever exhibits any variations which can be rendered sensible by chemical tests.

17. To the Memoirs of the Italian Society Fontana contributed several short essays; the first, entitled *Principi generali della solidità e della fluidità dei corpi*, vol. i. p. 89, Verona, 1782, containing the prevalent theories of the day respecting the change in the forms of aggregation of the same substance, together with experiments on the elasticity of different gases. 18. The second is a collection of definitions, entitled *Sopra la luce, la fiamma, il calore e il flogisto*, p. 104, characterizing these supposed elementary principles according to the ideas of Bergman, Scheele, and others. 19. In a later volume, v. p. 581 (1790), we find a *Lettera del Cavaliere F. Fontana al Sign. de Morveau*, in which it is conjectured that inflammable air may be a compound of phlogiston and water, and it is observed that the white crusts of flints contain as great a proportion of pure silica as their internal parts. Our author remarks, however, that his attention had of late been much distracted from chemical pursuits by the attention required for the completion of his collection of wax models of anatomical subjects, and for the duplicates which he was preparing for the cabinet of Vienna at the request of the emperor. At a subsequent period another series of copies of these models was ordered by Bonaparte to be sent to Paris; but it was there judged inferior to the preparations already existing in the Ecole de Médecine, which had been made under the direction of Laumonier, and Fontana's collection was sent to the university of Montpellier. He was latterly engaged for some time in the preparation of a colossal model of a man, built up anatomically of all his component parts, which were accurately represented in wood; but this elaborate design was never completed.

20. He was also the author of a few other chemical and mineralogical papers of less importance; for instance, of an *Analyse de la Malachite, Journ. Phys.* xi. p. 509; and, 21. A *Lettre sur du vitriol de Magnésie trouvé dans des carrières de gypse, en Piémont, Journ. Phys.* xxxiii. p. 309. 22. His last work is entitled *Principes raisonnés de la Génération.* He was also meditating an essay on the revivification of animals, but he did not live to complete it. A collection of his works, translated into French by Gibelin, was published at Paris in 1785, entitled *Observations Physiques et Chimiques.*

Fontana had become acquainted with a great number of contemporary men of science, by having travelled in various parts of Europe for the purpose of enriching the cabinet of which he was superintendent: the same official situation brought him into contact with all foreigners of distinction who passed through Florence in their travels; and he seems to have enjoyed a more extensive reputation than many philosophers of deeper research and more irresistible penetration. He wore the habit of an ecclesiastic, and was not uncommonly called abbé. He was well received in the best societies, though his manners are said to have been sometimes a little at variance with the dress which he adopted. He was treated with great respect by the French generals when they took possession of Tuscany in 1799, and hence he became the object of some suspicion upon the return of the Austrians, especially with the insurgents of Arezzo, who preceded them, and by whom he was for a short time imprisoned. His last illness was occasioned by an accidental fall in the street, on the 11th of January 1805, and he died the 9th of March 1806, at the age of seventy-five. He was buried in the church of the Holy Cross, not far from the tomb of Galileo. His Eloge was pronounced by Professor Mangili, in the university of Pavia, on the 12th November 1812. (Cuvier, in *Biographie Universelle*, vol. xv. 8. Par. 1816.) (L. L.)

FONTANA, *Gregory*, a profound mathematician and natural philosopher, younger brother of Felix Fontana, was born at Villa de Nogarola, near Roveredo, on the 7th December 1735.

He received the first rudiments of his education at Roveredo, and continued his studies at Rome, where he entered into the *Scuole Pie*, and soon distinguished himself by his talents and assiduity. He was entrusted with the care of a part of the public instruction in the school called the Collegio Nazareno, and was soon afterwards sent as a professor to Sinigaglia. It was here that he formed an intimacy with the Marquis Fagnani, whose example and assistance contributed very much to the advancement of his mathematical studies, to which he very soon in a great measure confined his attention. He was then removed by his superiors to Bologna; but his co-operation was found more necessary for the pious schools which had lately been established at Milan, and he there obtained the patronage and friendship of the Count de Firmian, the Mæcenas of the day, who greatly encouraged the publication of his first works. From these works he acquired so much credit, that he was summoned in 1763 to occupy the chair of logic and metaphysics in the university of Pavia; and he was appointed by Firmian director of the public library which he founded about the same time for the university. Two years afterwards he was advanced to the professorship of the higher mathematics, which had become vacant by the death of the celebrated Boscovich, and he filled this situation with high reputation for thirty years. He was the author of a great variety of memoirs, and did not even disdain the labour of a translator, when he thought that it could be useful to his pupils or his countrymen; but he never engaged in any single original work of great extent; for notwithstanding his habitual industry, his disposition was too volatile to allow him to confine himself long enough to any one object to effect any striking innovation in the complexion of the sciences which he cultivated. He was assiduous in the duties of his professorship; and his personal intercourse with society was extremely limited, though his correspondence with men of science was extensive. He was in the habit of writing many notes in the margin of the books that he read; and the volumes which composed his library acquired a double value from this circumstance. In April 1795 he was elected a foreign member of the Royal Society of London. About this time his health began to decline, and his physicians considered him as having suffered from too great application to his studies. In 1796 he received great marks of respect from Bonaparte, then commanding the French army in Italy; and he was made a member of the legislative body of the newly erected Cisalpine republic. In 1800, having resigned the professorship at Pavia, he came to Milan, and was afterwards nominated one of the Electoral College of the Dotti. He was still occupied in a variety of literary pursuits, when he was attacked by a violent fever, which caused his death at Milan, on the 24th August 1803. He left his manuscripts to his brother Felix, who died soon after him. An unmarried sister survived them both, and inherited the little property of her brothers, which was soon exhausted, and she was reduced to the extremity of distress. At last, finding no protection in a country to which her family had done so much honour, she became desperate, and drowned herself in the canal of Milan.

1—7. Fontana's principal publications were, first, seven Academical Dissertations on various departments of mathematical and mechanical science, among which are the *Analyseos Sublimioris Opuscula*, 4. Ven. 1763, and the *Memorie Matematiche*, 4. Pavia, 1796. 8—23. There are sixteen short memoirs in the *Atti dell' Accademia di Sienna.* Their subjects are, 8. *Astronomical Problems*, vol. v. 1774, p. 55. 9. *Theorems relating to the Integral Calculus*, p. 69. 10. *Remarks on Incommensurable Quantities*, p. 71. 11. *On the Quantity of Air in the Atmosphere*, p. 76. 12. *On the Area of a Spherical Triangle*, p. 83. 13. *On the Binomial Theorem*, p. 88. 14. *On Accelerated Motion*, p. 92. 15. *On Projectiles*, p. 97. 16. *On a Phenomenon of Vision*, p. 103, attempting to explain the comparative brightness of an object seen by one and by both eyes. 17. *On the Effect of the Solar and Lunar Attraction upon the Height of the Barometer*, p. 116. 18. *On the Mathematical Discoveries of Cardani and Cavalieri.* 19. *An Essay on the Gradual Renewal of the Blood of an Animal, and on the Principles of Compound Interest and Discount*, vol. v. 1781, p. 161. 20. *On the Axis of Equilibrium*, p. 173. 21. *On Curves described by the Centre of Gravity*, p. 177. 22. *On the Centres of Gravity of Hyperbolic Spaces or Figures*, p. 180. 23. *On Indefinite Equations, and on the Method of Indeterminates*, p. 184.

24—40. There are also a great variety of papers in the *Memorie della Società Italiana delle Scienze.* Among them we have, 24. *An Essay on the descent of a Body on a Convex Surface*, vol. i. Verona, 1782, p. 94. 25. *Remarks on the Measurement of Light*, p. 111, in which the elegant experiments of Lambert are applied to the explanation of the uniformity of the light of the sun's disk; an essay which would have saved a great Parisian astronomer some useless labour and calculation, if it had excited his attention. 26. *On the Logarithms of Negative Quantities*, p. 183. 27. *On the Equation of a Curve on Two False Theorems and on Harmonic Series*, vol. ii. 1784, p. 423. 28. *On the Pressure of Fluids*, p. 192. 29. *On Centrifugal Force*, p. 325. 30. *On Series*, p. 326. 31. *On Converging Series formed by the Products of the odd and even numbers*, vol. iii. 1786, p. 174. 32. *Analytical Researches on Refraction, on Perpetual Motion, on the Integration of Equations, on Collision, on the Resolution of Forces, and on the Pressure of Beams.* There is also an *Essay on Buffon's Combination of Mirrors*, and another *on the Quantity of Light Reflected by a Mirror in a given Direction.* 41—51. Five papers of Fontana appear in the *Memoirs of the Academy of Turin for* 1804, five in the *Biblioteca Fisica d'Europa*, and four in the *Physico-medical Journal of Pavia.* Of these, one of the most interesting relates to the *Magnifying Power of Telescopes*, and is reprinted in the fifteenth volume of the *Raccolta di Opuscoli*, published at Milan.

55. Of his translations, the principal are *La Dottrina degli azzardi di Abram Moivre*, Pavia, 1776, with additions, said to be a piratical publication. 56. *Saggio di una difesa della Divina Revelazione, di L. Eulero*, Pavia, 1777. 57. *Dissertazione di Mosheim sopra l'opera di Origene contro Celso*, Pavia, 1778, with notes. 58. *The Hydrodynamics, and other Mathematical Works of Bossut*, Sienna, 1779. 59. *Compendio di un corso di Fisica del Sign. G. Atwood*, Pavia, 1781. 60. *Saggio sopra i principi della composizione storica, del Sign. Hill*, Pavia, 1789, with an appendix. 61. *Discorso Preliminare agli atti della Società Linneana di Londra, del Sign. J. O. Smith*, Pavia, 1792. 62. *Sermone sul Martirio del re Carlo I. dal Dr G. Swift*, Pavia, 1798. 63. *L'Esempio della Francia, avviso e specchio all' Inghilterra, di A. Young*, Pavia, 1794. (Guillion *in Biographie Universelle*, vol. xv. Paris, 1816.) (L. L.)

FONTENAY, an arrondissement of the department of Vendée, in France, extending 1116 square miles. It is divided into eleven cantons, and subdivided into 161 communes, and contains 117,524 houses. The capital is a city called Fontenay Le Comte, situated in a valley through which the Vendée runs. It is an ill-built, old-fashioned town, distinguished only by its lofty tower on the mother church, which is 294 feet in height, and very beautiful. It contains 1485 houses, and 6615 inhabitants. It has some trade in linen and woollen goods. It has not yet recovered from the effects of the revolution. Long. 2. 3. W. Lat. 36. 40. N.

FONTENELLE, BERNARD LE BOVIER DE, was born at Rouen on the 11th February 1657, and died at Paris on the 9th January 1757. It was during this interval of time, comprehending an entire century, that the greatest writers France has produced commenced or terminated their career; and amongst these illustrious men, who were all either the friends, the enemies, or the rivals of Fontenelle, none was more remarkable whilst living, or has been more celebrated since his death. For this advantage he has been principally indebted to the variety of his acquirements, the fineness of his genius, and the versatility and grace of a talent peculiarly French, which seems to have acquired its greatest perfection, and displayed itself in the happiest manner, in the country which gave him birth, and in the age when he flourished. Fontenelle received his education in the college of Jesuits at Rouen, where the quickness and aptitude of his powers became conspicuous at a very early period. When only thirteen years of age he commenced the study of rhetoric; and so rapid was his progress, that in a note opposite his name on the register of the college, he is described as *adolescens omnibus partibus absolutus, et inter discipulos princeps.* At the desire of his father he studied the law; but as he lost the very first cause in which he was employed as an advocate, he became disgusted with his profession, and devoted himself entirely to literature and philosophy. He composed a considerable part of the operas of *Psyche* and *Bellerophon*, which were printed under the name of his uncle Thomas Corneille; and he also wrote a tragedy called *Aspar*, but as it did not succeed, he consigned the manuscript to the flames, and never afterwards attempted that species of composition. His *Dialogues des Morts* were published in the year 1683, and well received as a specimen of elegant composition, combining morality with the charms of literature; in fact, this work laid the foundation of the great reputation of Fontenelle. His *Lettres du Chevalier d'Her*, published in 1685, without his name, discovered much wit and ingenuity, but at the same time no small share of affectation, and obtained only moderate success. But his *Entretiens sur la Pluralité des Mondes* has been regarded as one of his ablest performances, combining science and philosophy with vivacity and humour, a talent which may be said to belong almost exclusively to the French nation. It was universally read, and translated into several foreign languages. In his *Histoire des Oracles* he supported the opinion that oracles were forgeries, in opposition to those who contended that they were supernatural operations of evil spirits, put to silence by the appearance of Christ, and consequently exposed himself to much clerical animadversion. Le Tellier denounced the book, and the Jesuit Baltus attempted to refute it; whilst others, again, wrote as warmly in its defence, contending that the opinion therein maintained was conformable to that of the most renowned theologians. Fontenelle took no part in the dispute, but contented himself with writing to M. Leclerc, "It belongs rather to M. Van-Daale than to me to answer on this occasion; he is my guarantee, I am only his interpreter; and I have no objection that the Devil should be a prophet since the Father Jesuit wishes it so, and considers it the more orthodox opinion." His Pastoral Poems, which appeared in the year 1688, with a discourse on the nature of the eclogue, were very much admired for their delicacy of sentiment, as was also his opera of Thetis and Peleus; but his Æneas and Lavinia was not so successful. In the year 1699 Fontenelle was chosen secretary of the Academy of Sciences, which office he held during the long period of forty-two years. Whilst in this office he published annually a volume of the history of that learned body, entitled *Histoire de l'Académie des Sciences,* filled with analyses of memoirs, and éloges on deceased members. Besides his labours as secretary, he also made his contribution as an academician, by composing his *Géométrie de l'Infini,* a work of which he jocularly observed that there were only eight men in Europe in a condition to understand it, and that the author was not one of the number. It appears, however, that Fontenelle was by no means profound in the mathematics; and hence, with the exception of a preface to the *Analyse des Infiniments Petits* of L'Hôpital, and a memoir on the extension of the property of the number *nine,* he produced no other works on the subject. As a poet, Fontenelle did not rise above elegance and ingenuity; as a man of science, he excelled in throwing light on the inventions of others, rather than in discovering new truths himself; and as a general writer, he united solid sense with the delicacy and refinement of a man of wit. He studied his own comfort as much as most men, but never sacrificed to selfish gratification the duties of a man of honour and of virtue. He had many friends, and towards the close of his life scarcely a single enemy. He was never married, and, for a man of letters, had acquired considerable affluence. Although of a delicate constitution, he reached the age of ninety without any complaint except deafness; and died, as already mentioned, on the 9th of January 1757, being within a few days of a hundred years of age. When asked by a certain person how he could pass so easily through the world, he replied, by virtue of two axioms, namely, that all is possible, and that every one is in the right.

There are only two complete editions of the works of Fontenelle; one in eleven volumes 12mo, Paris, 1758, 1760; and the other in eight volumes 8vo, Paris, Bastien, 1790. In these editions are found the Prefaces and Eloges which form part of the History of the Academy of Sciences; but they contain neither the Analyses nor the *Géométrie de l'Iufini,* which first appeared in 1727, 4to. The edition of the *Œuvres Diverses,* published at the Hague, 1728, 1729, is much sought after on account of the engravings of Bernard Picard. But the work of Fontenelle which has been most frequently reprinted is his *Entretien sur la Pluralité des Mondes.* The first edition appeared in the year 1686; but the sixth conversation, composed long afterwards, was only printed in the edition of 1719. The principal other editions are that of Dijon, Causse, 1793, in 8vo; that of Didot, 1796, in 4to; and that printed in 1800, with the notes of Lalande, which is the best. In 1730 there appeared at Leipsic, in 8vo, a German translation by Gottsched; in 1751, an Italian translation by Vestrini, published at Arezzo; and there are three English translations, the best of which was published in 1760, in 8vo.

FONTENOY, a village of the Netherlands, in the province of Hennegau, and circle of Tournay, containing 580 inhabitants. It is memorable for the battle fought there in 1745, in which the allies commanded by the Duke of Cumberland were defeated by the French under Marshal Saxe.

FONTEVRAUD, or FONTEVRAUX, *Order of,* in *Ecclesiastical History,* a religious order, instituted about the latter end of the eleventh century, and taken under the protection of the holy see by Pope Pascal II. in 1106, confirmed by a bull in 1113, and invested by his successors with very extraordinary privileges. The chief of this order was a female, appointed to inspect both the monks and nuns. The order was divided into four provinces, which were those of France, Aquitaine, Auvergne, and Bretagne, in each of which they had formerly several priories.

FONTINALIA, or FRONTANALIA, in *Antiquity,* a religious feast held amongst the Romans in honour of the deities who presided over fountains or springs. Varro observes that it was the custom to visit the wells on certain days, and to cast crowns into fountains. Scaliger, in his conjectures on Varro, supposes that this was not a feast of fountains in general, as Festus insinuates, but of the fountain which had a temple at Rome, near the Porta Capena, called also *Porta Fontinalis;* and he adds, that it is of this fountain Cicero speaks in his second book *De Legibus.* The Fontinalia were celebrated on the 13th of October.

FOOD.

OUR observations upon this subject may be conveniently arranged as relating to the *Selection, Preservation,* and *Preparation* of the various substances which are commonly used for food.

SELECTION.

General observations.

Animal matters in general are safe articles of food. In regard to the higher classes, the mammalia and birds, this is universally true of those in a state of health. A few exceptions occur among the fishes, depending either upon the constitution of certain persons, who are injuriously affected by substances generally alimentary, or upon some singularity in the nature of the individual fish, by which it becomes poisonous, although the species is generally nutritious and wholesome. As we descend still lower in the scale, these exceptions occur more frequently, and more species are absolutely and universally unwholesome, or furnish poisons hurtful to every constitution. In the vegetable kingdom, the alimentary vegetables form but a small proportion of the whole, and almost an equal number are absolutely poisonous, or at least injurious, except when

Quadru peds.

given in small quantities, to counteract some existing disease.

Although quadrupeds, without exception, furnish articles which may be safely used as food, their flesh differs much in palatability, and probably in its nutritious qualities. There is also no part of this class of animals that may not be, and indeed is not occasionally used as food, although the flesh, or voluntary muscles upon the limbs, trunk, and head, is by far the most considerable and important. The heart, the largest of the involuntary muscles, is also commonly eaten; and the brain and spinal marrow or pith; all the glands, the kidneys, liver, udder, and sweetbread; the compound internal organs, the lungs, stomach, and intestines, the uterus, placenta, and even the contents of the stomach, the fat and marrow of the bones, the blood and skin, are all nutritious, and some of them highly prized; and even the bones themselves can be made to furnish much wholesome nutriment. The milk of all quadrupeds is also alimentary, and generally agreeable.

These various organs, although each of them contains several immediate principles, considered chemically, are characterized by some difference in their composition. The muscular flesh consists principally of fibrine, combined with some gelatinous mucus and osmazome; the tendons of the muscles, on the contrary, are little else than gelatine in a very dense form. This is likewise the case with the skin, the membranes in general, and the ligaments. Brain and medullary nervous matter consist chiefly of coagulated albumen, which also, perhaps, enters largely into the composition of glands. The fat, suet, and marrow of the bones, are different forms of concrete animal oil. All these principles are digestible and nutritious, but in what comparative degree is far from being ascertained. According to popular opinion, it is nearly inversely as their solubility in water, muscular flesh being considered to furnish the strongest aliment, and gelatinous organs the lightest. But these substances are not exactly similar in all animals, nor even in the same animal at different periods of life.

Size.

In general the flesh and other parts are coarser in proportion to the size of the animal, not only when different in kind, but in different varieties of the same species, although well-grown individuals of the same variety are always better than those which have not been sufficiently nourished. Thus the flesh of the elephant and rhinoceros have been found to be very coarse and unpalatable, whilst that of the rat and smaller quadrupeds is very delicate. The larger varieties of the ox and sheep, also, are inferior to the smaller, as the kyloes of the Western Islands, and the sheep of Wales and the Highlands of Scotland.

The whole organs of young animals are much more gelatinous than those of the adult and aged, whilst these contain more fibrine and extract. Hence the flesh of young animals is more bland and tender, and yields most to the action of boiling water; whilst that of aged animals is more savoury, even to rankness, and is firm to toughness.

The flesh of very young animals is to our palates unpleasantly soft and flabby, qualities of which every one is a judge; but it is at no period of life, not even in the fœtal state, actually unwholesome; and therefore there was no rational ground for that enactment which provided that no butcher shall kill any calf to sell being under five weeks old. The fact is, that cows large with calf are frequently killed, and the fœtus is always sold as very young veal, and preferred by some people. By our butchers, calves are killed at from six to sixteen weeks; but they are reckoned best at ten or twelve. Lambs are generally killed at from eight weeks to half a year.

The flesh of quadrupeds in the vigour of life is more stringy, and again becomes shorter as it advances to old age, when it becomes dry and unnutritious. Young animals also differ from those that are aged, in the distribution of the fat, which in the latter is chiefly collected in masses or layers external to the muscles, and in the former is more interspersed among the muscular fibres, giving the flesh a marbled appearance, which is always a desirable property in butcher-meat.

The beef of the larger breeds of oxen is in perfection when the animal is about seven years old, that of the smaller breeds a year or two sooner. Cow beef, on the contrary, can scarcely be too young. The flesh of a young heifer is highly esteemed; that of an old fattened cow is very bad. Wedder mutton is in perfection at five years. Ewe mutton is best when about two years old. Sucking pigs are killed about three weeks old; but pork differs from other kinds of butcher-meat in not requiring age to mellow it; so that swine for pork are killed at from six to twelve months old; but for brawn, age is an advantage, or rather necessary. The buck of the fallow-deer may be killed at six, but is better at eight years of age. The female in general being naturally more tender, and getting tough rather than mellowing by age, is sooner in perfection.

Sex.

The sex also greatly influences the quality of the flesh, that of the female being always more delicate and finely grained than that of the entire male, of which the fibres are stronger and the taste more rank. Indeed the influence of the genital organs on the flesh of animals is very remarkable. The delicacy of the flesh, even of the female, is greatly improved by removing the ovaries, or "spaying" them as it is called. Every day the testes are permitted to remain, even though totally inactive as to their proper function, injures the delicacy of the veal of the bull-calf; and an animal which is not castrated until after puberty always retains much of the rankness and coarseness of the entire male. Daubenton[1] directs that the male lambs should be castrated at from eight to fifteen days after their birth, although it is not usual to perform the operation until the age of three weeks, or even five or six months. But their flesh is never so good as when they are castrated at eight days. Huzard goes farther, and recommends it to be performed in a day or two after their birth, or as soon as the testes descend into the scrotum. The female lambs are also spayed occasionally in France, to render their flesh more delicate, and to improve the wool; but the operation cannot be performed until the ovaries have acquired a sufficient size to be brought out with the finger, when about three weeks old. In this country the sow pigs which are not reserved for breeding are all spayed when about four weeks old; the boar pigs are castrated a week sooner. On the other hand, the males of those races in which the testes are active only at certain seasons, as the deer tribe, have the coarse rank flesh of entire males only when rutting, and at all other times they much more resemble the castrated individuals of those animals, such as the bull, which are always capable of procreating their species. Even with the ram there is a short period when the flesh is less rank, and during the rutting season it is intolerable. Buck venison is highly esteemed, and the boar is preferred for making brawn.

Food.

The manner in which the animal has been fed has also considerable influence on the quality of the flesh. Generally the lean of fat animals is better than that of those that are poor, and perhaps an animal in a state of nature can never be too fat. Artificial fattening may, however, be carried too far; and the practice of feeding oxen

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[1] Daubenton, *Instruction pour les Bergers, publiée par ordre du Gouvernement, avec des notes* par J. B. Huzard, 4me ed. augmentée, 8vo. Paris, 1810.

Selection of Food.

on oil-cake for the market is now almost laid aside, as the beef acquires from it an unpleasant rancidity. Also unwholesome fatness, such as that which takes place in the first stage of the rot, and which, it is said upon very good authority, some butchers induce artificially, is certainly not desirable. “ Several graziers and butchers having observed that sheep are much disposed to feed during the first stage, or four weeks after being tainted, omit no opportunity of producing it to increase their profits.”[1] But it is not only in regard to fatness that the flesh of animals is affected by the nature of their food, for its flavour is materially altered by it, and an epicure will readily distinguish by the taste, whether mutton of the same race has been fed upon turnips, or upon the natural grasses of a Highland farm.

The effect of the food is more apparent in pork than in any other kind of butcher-meat. The fat of pigs fed on skimmed milk, though sour, is firmer, and vastly superior to that of hogs fed upon peas or meal. And Mr Jackson says we have no pork in England or Ireland equal to that of Sardinia, where the hogs are almost wild, and fattened upon chestnuts.

Season.

The season of the year has considerable influence on the quality of butcher-meat, though less than upon other kinds of aliment. Its influence depends upon the more or less plentiful supply of food, upon the periodical change which takes place in the body of the animal, and upon temperature. *In season* and *out of season* are words often vaguely applied, meaning, most commonly and correctly, the period of the year in which the substance in question is naturally best and worst, but also occasionally expressing the good or bad condition of the individual animal, without any regard to the state of the species in general; and lastly and most improperly, meaning that it is at that time desired or rejected by the higher classes of society as being rare or common. The flesh of most full-grown quadrupeds is in highest season during the first months of winter, after having enjoyed the advantage of the abundance of fresh summer food. Its flavour then begins to be injured by the turnips given as winter food, and in spring it gets lean from deficiency of food. Although beef and mutton are never absolutely out of season, or unfit for the table, they are best in November, December, and January. Pork is absolutely bad or out of season during the summer months, and is only good in those of winter. The males of the deer tribe are in highest season from the middle of June to the beginning of September, when they begin to rut, after which they become thin and exhausted. Females in general are out of condition when they are suckling, or have lately suckled or given milk. Does which have had no kids, or were soon deprived of them, follow the general rule of castrated animals, and are in season from the middle of November to the middle of February. Their condition is not much affected during the first months of pregnancy. The season of the year when the young of quadrupeds have acquired the proper age for being used as aliment is the period when they are in season. This is naturally in the summer months, when lamb, veal, kid, and fawns are most abundant. But breeders continue to furnish the tables of the wealthy with the first two of these at almost every season of the year, by selecting certain breeds, such as the Dorsetshire sheep, which lamb very early, or by treating them in such a way as to cause the female to come in heat at an unnatural time. In this way lamb is procured as an article of luxury as early as November and December; and, on the contrary, by keeping the ewe on a cold and poor hill pasture, the lambing season is retarded.

Mode of killing.

The mode of killing has considerable effect on the flesh of the animal. Most of those slaughtered for food are either bled to death, or are bled profusely immediately after being deprived of life in some other way.

The common mode of killing cattle in this kingdom is by striking them on the forehead with a pole-axe, and then cutting their throats to bleed them. But this method is cruel, and not free from danger. The animal is not always brought down by the first blow, and the repetition is difficult and uncertain; and if the animal be not very well secured, accidents may happen. Lord Somerville,[2] therefore, endeavoured to introduce the method of pithing or laying cattle, by dividing the spinal marrow above the origin of the phrenic nerves, as is commonly practised in Barbary, Spain, Portugal, Jamaica, and in some parts of England; and Mr Jackson says, that “ the best method of killing a bullock is by thrusting a sharp-pointed knife into the spinal marrow, when the bullock will immediately fall without any struggle; then cut the arteries about the heart.”[3] Although the operation of pithing is not so difficult but it may, after some practice, be performed with tolerable certainty, and although Lord Somerville took a man with him to Portugal to be instructed in the method, and made it a condition that the prize cattle should be pithed instead of being knocked down, still pithing is not becoming general in Britain. This may be partly owing to prejudice; but we have been told that the flesh of the cattle killed in this way in Portugal is very dark, and becomes soon putrid, probably from the animal not bleeding well, in consequence of the action of the heart being interrupted before the vessels of the neck are divided. It therefore seems preferable to bleed the animal to death directly, as is practised by the Jew butchers.

The Mosaic law so strictly prohibits the eating of blood, that the Talmud contains a body of regulations concerning the killing of animals; and the Jews, as a point of religion, will not eat the flesh of any animal not killed by a butcher of their own persuasion. Their method is to tie all the four feet of the animal together, bring it to the ground, and, turning its head back, to cut the throat at once down to the bone with a long, very sharp, but not pointed knife, dividing all the large vessels of the neck. In this way the blood is discharged quickly and completely. The effect is indeed said to be so obvious, that some Christians will eat no meat but what has been killed by a Jew butcher.

Calves, pigs, sheep, and lambs, are all killed by dividing at once the large vessels of the neck. Animals which are killed by accident, as by being drowned, hanged, or frozen, or by a fall or ravenous animal, are not absolutely unwholesome. Indeed they only differ from those killed methodically in not being bled, which is also the case with animals that are snared, and in those killed by hounds. Animals which die a natural death should never be eaten, as there are undeniable instances of disease, and even death, being the consequence.

Animals frequently undergo some preparation before they are killed. They are commonly kept without food for some time, as, if killed with full stomachs, their flesh is considered not to keep well. Oxen are commonly fasted two or three days, smaller animals a day; but it is evident that the practice must not be carried too far, as the opposite effect will be produced by the animal falling off or getting feverish. It is generally understood that, in order to have veal very white, the calf is repeatedly bled largely before it is killed. But the practice does not seem to be very common. It is altogether denied by the feeders, and not confessed by the butchers. We are not, therefore, able to say what its effects would be; but Dr Lister has stated that nothing contributes more to the whiteness and tenderness of the flesh of calves than often bleeding them, by which the colouring matter of the blood is exhausted, and nothing but colourless serum remains. A much more cruel method of preparation for slaughter used to be practised, though now much less frequently, in regard to the bull. By some ancient municipal laws, no butcher was allowed to expose any bull-beef for sale, unless it had been previously baited. The reason of this regulation probably was, that baiting had the effect of rendering the flesh or muscular fibre much more tender; for it is a universal law of the animal economy that, when animals have undergone excessive fatigue immediately before death, or have suffered from a lingering death, their flesh, though it becomes sooner rigid, also becomes sooner tender than when suddenly deprived of life in a state of health. The flesh of hunted animals also is soon tender and soon spoils;[1] and it is upon this principle only that the quality of pigs' flesh could be improved by the horrid cruelty, said to be practised by the Germans, of whipping the animal to death. Another part of the same receipt, to roast a pig wild-boar fashion, consists in making him swallow, some hours before death, a quantity of vinegar aromatised with herbs. We notice this, because we think the action of vinegar given to animals some hours before death, in rendering the fibre mellow, deserves to be examined. It is a common practice in the country to give poultry a spoonful or two of vinegar some time before they are killed, when they are to be dressed immediately. Popular practices are seldom without some foundation, and with this, the fact that acetic acid or vinegar has a peculiar chemical action upon fibrine connects itself. The Moors in West Barbary, before they kill a hedgehog, which is esteemed a princely dish among them, "rub his back against the ground, by holding his feet betwixt two, as men do a saw that saws stones, till it has done squeaking, and then they cut its throat." (Mr Jones, *Phil. Trans.* No. 254.)

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[1] *An Inquiry into the Rot in Sheep and other Animals.* By Edward Harrison, M.D. F. R. A. S. Ed. &c. 8vo. London, 1804.

[2] *General Survey of the Agriculture of Shropshire.* By Joseph Plymley, M. A. 8vo. London, 1803, p. 243.

[3] *Reflections on the Commerce of the Mediterranean.* By John Jackson, Esq. F. S. A. 8vo. London, 1804, p. 91.

Birds.

There is no bird, and no part of any bird, nor any bird's egg, which may not be safely used as food. Gmelin quotes a singular instance of some persons having been much affected after eating larks; and suspects that the flesh of the birds may have been rendered poisonous by their having fed upon hemlock-seed, which they eat with impunity. But there can be no doubt that this must be a mistake, for larks are a common and favourite food in the very country where this accident is said to have happened.

The flesh of birds differs very much in its sensible properties, not only in different kinds, but even in the different muscles of the same bird. The pectoral muscles which move the wings are whiter, drier, and more tender than those which move the legs. The tendons of the legs are also very strong, and at a certain age become bony; but the flesh of the legs, when sufficiently tender, either from the bird being young, or from long keeping, or sufficient cookery, is more juicy and savoury than that of the wings. Of a few birds, especially the woodcock and snipe, the legs are at all times preferred to the breast. In the black-cock, the outer layer of the pectoral muscles is of a dark-brown colour, while the inner is white. A similar difference is observed in many other birds, and perhaps it is general in a slight degree. The muscular organs of birds differ from those of quadrupeds in their flesh never being marbled, or having fat mixed with the muscular fibres.

There is a great diversity in the flesh of the different classes of birds; but no very accurate distribution of them in this respect can be made, as, though the extremes are sufficiently marked, they run insensibly into each other. We may, however, notice, as sufficiently distinct, 1. the white-fleshed, exemplified in the common fowl and turkey; 2. dark-fleshed, game, grouse, black-cock; 3. aquatic, goose, duck; and, 4. rapacious, hawks and owls. Several species of the first and third classes are domesticated, and reared in great numbers as esteemed articles of food. The white-fleshed birds are very generally liked, when good of their kind, and by many are preferred to game, which, however, when sufficiently kept, is one of the greatest luxuries of an epicure's table. It has then acquired a peculiar odour, called *fumet*, and an aromatic bitter taste, most sensible in the back. The aquatic birds, both swimmers and waders, are generally eaten, and many of them are very delicate; but in general they are disposed to become very fat, and often acquire a rancid and fishy taste. This is chiefly connected with the fat, and may be somewhat avoided by skinning the bird, and removing the inside fat, before cooking. Of the rapacious birds none are eaten, partly perhaps from prejudice, and partly because those which touch carrion acquire a cadaverous smell.

The muscular fibre is coarser in the larger than in the smaller birds of the same class, and it becomes less tender as they get older. It is also much influenced by sex, although of some birds the young cock is preferred, chiefly, we apprehend, on account of its greater size and handsome appearance. By removing the sexual organs at an early age, both sexes are much improved for the use of the table, becoming larger, fatter, and more tender, as we see in the capon and poulard. The manner in which birds are fed affects both their fatness and their flavour. Birds seldom get very fat in their wild state, or when domesticated, if allowed to go at large. The art of fattening poultry consists in supplying them with abundance of healthy food, and confining them. Aquatic birds, ducks and geese in particular, must be prevented from going into the water, both because they never get fat, but also acquire a rancid fishy taste.

Modes of fattening.

The fattening of fowls for the London market is a considerable branch of rural economy in some convenient situations. "They are put up in a dark place, and *crammed* with a paste made of barley-meal, mutton-suet, and some treacle or coarse sugar, mixed with milk, and are found to be completely ripe in a fortnight. If kept longer, the fever that is induced by this continued state of repletion renders them red and unsaleable, and frequently kills them."[2] But fowls brought to this state of artificial obesity are never so well flavoured in the flesh, and probably not so salubrious, as those of the same species fattened in a more natural way. The great secret of having fine pullets is cleanliness, and high keeping with the best corn.

Epicures in all ages have been exceedingly whimsical in the selection of certain parts of particular birds as dainties, and the ancients more so than the moderns; for although we still prize the combs of the common fowl, the trail of the woodcock, and even collect with care the dreg which drops from it in the process of roasting, the guts of the bustard, the gizzard and liver of the goose, and the feet of the duck; we find that Roman epicures delighted in the brains of ostriches and parrots, the tongue of the flamingo, and the enlarged liver of the goose. The last still continues among our continental neighbours to be in great request, and the providing them is a considerable branch of rural economy in some provinces. It is said that, at Strasburg, it is effected by actually sewing up the anus of the tortured animal, after a certain preparation; but we have not met with the barbarity set down in print, and it is perhaps not true, otherwise so striking an exemplification of Sir E. Home's doctrine, that the fatness of animals depended upon the length of their intestinal canal, and the length of time the fæces were retained in it, would not have escaped his notice. The process followed in different parts of France is described at length by Sonnini:[1] "The object of the third method is to enlarge the liver. Nobody is ignorant of the endeavours of sensuality to cause the whole vital forces to be determined towards this part of the animal, by giving it a kind of hepatic cachexy. In Alsace, the individual buys a lean goose, which he shuts up in a small box of fir, so tight that it cannot turn in it. The bottom is furnished with a wide grating of rods, for the passage of the dung. In the fore part there is a hole for the head, and below it a small trough is kept always full of water, in which some pieces of wood charcoal are left to steep. A bushel of maize is sufficient to feed it during a month, at the end of which time the goose is sufficiently fattened. A thirtieth part is soaked in water each night, and crammed down its throat next day, morning and evening. The rest of the time it drinks and guggles in the water. Towards the twenty-second day they mix with the maize some poppy oil, and at the end of the month it is known by a lump of fat under each wing, or rather by the difficulty of breathing, that it is time to kill it, otherwise it will die of fat. The liver is then found weighing one or two pounds, and besides, the animal is excellent for the table, and furnishes, during its roasting, from three to five pounds of fat, which is used in the cookery of vegetables. Of six geese, there are commonly only four, and these are the youngest, which answer the expectation of the fattener. They are kept in a cellar, or place with little light; and the Roman epicures, who prized their livers, had already observed, that darkness was favourable to this kind of education, no doubt because it prevents all distraction, and directs the whole powers towards the digestive organs. The want of motion, and the difficulty of respiration, may be also taken into consideration; the first by diminishing the waste of the system, and both by retarding the circulation in the vena portarum, of which the blood ought to become hydrogenated, in proportion as its carbon unites itself to the oxygen, which that liquid absorbe. This favours the formation of the oily juice, which, after having filled the cellular system of the body, enters into the biliary system and substance of the liver, and gives it that fatness and size which is so delightful to the palates of true gourmands. The liver thus only becomes enlarged consecutively, and the difficulty of respiration does not appear till the end, when its size prevents the action of the diaphragm."

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[1] *Recherches de Physiologie et de Chimie Pathologique.* Par P. N. Nysten, 8vo. Paris, 1811.

[2] *Agricultural Report of Berkshire.* By William Mavor, LL. D. 8vo. London, 1813.

"The leanness of geese subjected to this treatment is often mentioned; but it can only occur in those whose eyes are put out, and feet nailed down to a board, as the consequence of this barbarous treatment. Among a hundred fatteners, there are scarcely two who adopt this practice, and even these do not put out their eyes till a day or two before they are killed. And therefore the geese of Alsace, which are free from these cruel operations, acquire a prodigious fatness, which may be called an oleaginous dropsy, the effect of a general atony of the absorbents, caused by want of exercise, combined with succulent food crammed down their throats, and in an under oxygenated atmosphere."

There are certain months in which each kind of bird is considered to be in season, and which are determined by the time of their breeding, the abundance of food, or their migration. Some birds do not remain with us all the year, and are therefore to be valued when we can get them. The migrating birds go farther south in winter, and north in summer. They are, therefore, with us in winter or summer, according to their habits in regard to temperature and the supply of food. Those birds which remain during summer breed here, and their young may be obtained before they fly, and whilst they are still delicate, as the gannet or solan goose; others, as the woodcock, rarely breed in this country, and are only got in their adult state.

There is but little diversity in the mode of killing birds. Game is almost always shot, as hawking is entirely out of fashion, although formerly birds killed in this way were more esteemed, as, indeed, their flesh would be sooner tender. Larks are caught in winter in traps and nets, and then killed. The heads are twisted off young pigeons; but domestic birds, in general, are killed in a very unskilful and barbarous manner. The common fowl has its neck drawn, by which the spine is torn asunder at an uncertain place; and if the spinal cord be not divided, or be divided too low, the animal dies slowly, and is sometimes alive after its feathers have been plucked off. The large blood-vessels are sometimes also torn across. This is an advantage, both from shortening the sufferings of the animal, and rendering its flesh whiter in consequence of the loss of blood. Turkeys are bled to death by dividing the vessels under the tongue. The only objection to this is that it is tedious, for probably it is not attended with much pain. Geese are killed by splitting the skull with a knife. This is sometimes very awkwardly performed, and neither any large vessels are divided, nor the nervous energy destroyed. Domestic birds are generally kept confined and fed upon choice food for some time before they are killed, and sometimes they are crammed, or forced to eat more than they would voluntarily. They should always be kept a day without food at the last, that their crops may be empty, as food left in them is apt to taint the flesh.

Of the reptiles, very few are used as food, though probably rather on account of their disgusting appearance, than of their being hurtful, or even unpalatable, as some of the greatest luxuries of the table belong to this class of animals. Besides the green turtle, several other species of *Testudo* are eaten, especially the *Græca*, *Europæa*, and *ferox*. Of the lizards, the *Dracæna*, *Amboinensis*, *agilis*, and *Iguana*, are eaten. The flesh of the last is said to be delicious, but unwholesome, especially to those persons affected with syphilis, which, however, is probably a vulgar prejudice. The *Lacerta scincus* is held in estimation by the natives of the east as aphrodisiac. The eggs of the *Iguana* and of most species of *Testudo*, even of those whose flesh is said to be bad, as of the *Imbricata*, are nutritious and agreeable. The flesh of the *Coluber natrix* is eaten in some places; and even the viper, whose bite is poisonous, furnishes a nutritious broth to invalids. Of the frogs, the *Rana esculenta* is a favourite article of food with our continental neighbours. The *Rana taurina*, or bull-frog, rivals the turtle in the opinion of our Transatlantic descendants. The *Rana bombina*, though a toad, is also eaten in some places as a fish. We have no doubt that many other reptiles are used as food in some countries; and we are not aware of a single instance where injurious effects have been produced by any that have been tried. Their flesh seems in general to be delicate and gelatinous; the fibre resembles that of chicken or veal; and what is called the green fat of turtle is in reality

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[1] *Nouveau Dictionnaire d'Histoire Naturelle*, art. *Oie.*

Selection of Food.

gelatinous, like the skin of calf's head, or the tendons of ox-heel, which are employed to make an imitation of it. We know little of the circumstances which influence the quality of reptiles as esculent; but the modern Apicius says, the best size of a turtle for taste is sixty pounds to eighty pounds, which is scarcely a tenth part of the size they sometimes reach; and we may presume that, like most other oviparous animals, they are best before they begin to lay their eggs, and out of season for some time afterwards. Turtles often become emaciated and sickly before they reach this country, in which case the soup would be incomparably improved by leaving out the turtle, and substituting a good calf's head.

In some places fish constitutes the sole or chief food of the people, hence called Ichthyophagi, and almost everywhere it is in request. In Siberia, dried fish is used instead of bread. The Laplanders make a bread of fish bones, and the Negroes of the western coast of Africa dry a species of sprat, and beat it in wooden mortars to a paste, which keeps all the year, and is eaten with rice or corn. Putrid fish is even the favourite and ordinary food of some tribes. Fish, however, is not so universally a safe aliment as the two preceding classes of animals; for although no species is generally unwholesome, yet, in some situations, individuals of many different species are absolutely poisonous, whilst others of the same species, and not to be distinguished by any certain external characters, at the same place, and in the same season, are innocent and nutritious, which render the eating of fish in such countries not free of danger.

Pois ous fish.

The subject of poisonous fishes is still involved in great obscurity, although so important to those who are exposed to suffer from them. It is not peculiar to any genus, species, or distinct variety, but occurs in individuals only, and those of several genera of very different classes, such as *Clupea, Perca, Boracinus, Sparus, Coryphœna, Scomber, Murœna, Balistes, Tetrodon*, and *Cancer*. Except the *Bogmarus Islandicus*, which is reputed poisonous by the Icelanders, because the crows refuse to eat it, poisonous fish occur chiefly in tropical seas. It is only at certain seasons, however, that any poisonous fish occur; as in the Carribbean Sea in May, June, and July, after having spawned. Their deleterious effects are ascribed by some to the fish feeding on poisonous substances, as on copper banks, medusæ, and holothuriæ, or the manchineel apple. The poison is supposed to exist in the gall; and it is said that if the peritoneum and all the entrails be speedily and dexterously removed, the flesh may always be eaten without danger. A fish is suspected when it is of an unusually large size, or is destitute of the natural fishy smell, or has black teeth, or when silver or an onion boiled along with it becomes black; but all these tests are uncertain. The poisonous quality is also said to be destroyed by salting the fish, or drinking along with it sea water, or the ripe juice of the lime, sugar cane, or sweet potato.

Some ancient, as well as modern naturalists and physicians, consider the roe of the barbel as unwholesome when eaten; others think it is hurtful only at certain seasons to certain individuals, and when eaten in excess; and, lastly, some declare the whole allegations to be erroneous and unfounded. Bloch, the great ichthyologist, and Bosc, both assert that they and others have eaten it without any inconvenience; but Dr Crevelt of Bonn has published cases which leave little doubt that in some cases the roe is actually injurious, although the flesh of the same individual was eaten with impunity.

The ancients had many prejudices in regard to the wholesomeness or unwholesomeness of certain fishes. The Egyptian priests were forbidden to eat fish of any kind, under the idea that it increased the sexual appetite, or that it was a cause of the leprosy. For the latter reason the people were forbidden to eat any fish not covered with scales. Moses adopted the same principle: "Whatsoever hath fins and scales in the waters, in the seas, and in the rivers, them shall ye eat." "Whatsoever hath no fins or scales in the waters, that shall be an abomination unto you."[1] Numa made a law for the Romans much to the same effect; but it did not continue in force, as we find the lamprey and sturgeon among the luxuries of the emperors; and such fish now form the chief support of the people in some districts, without being followed by any bad effect.

Fishes, however, present an infinite variety in regard to their fitness as articles of food, in the colour and texture of their muscles, and in being more or less gelatinous, fibrous, or oily. The muscles of many fish, with the exception of the heart, are quite white, and in general, when the fish is good, they become opaque when cooked. When they remain semitransparent and bluish after sufficient boiling, they are not in season. Of some fishes the flesh is a pale red at certain seasons, and the higher the colour of these kinds the more are they esteemed. Of most fishes the muscles are disposed in flakes, and when in perfection, there is, when cooked, a layer of white curdy matter between them, resembling coagulated albumen. Some other fishes, chiefly those that are flat, or eel-shaped, or without scales, have a fibrous flesh, not divisible into flakes. The liver of the fish tribe abounds with oil, and of many species the flesh is mixed or covered with oil or fat, as the eel or salmon; but of many others the flesh seems to be totally free from it, as all the varieties of the cod, haddock, whiting, and the flat fish.

Almost every soft part of fishes is nutritious, and occasionally eaten. The great bulk of the animal consists of the muscles of voluntary motion, covering the spine and its appendages; but of some fishes, as turbot, ling, &c. the pulpy gelatinous skin is esteemed. Cod-sounds are the swimming bladders of the large cod, and they are preserved separately, and transmitted to the capital for the gratification of our epicures. In the fresh fish, the tongue, palate, and lips, although too soft for most people, are preferred by some. The roe of most fishes is eaten, and that of some constitutes a principal article of national food. Caviare is the preserved roe of the sturgeon. The melt or soft roe of the herring is eaten by many. The liver of the burbot is very large, and is much esteemed. The enormous *vas deferens* of the male cod fried is one of the best garnishes for that fish; and some of the smaller and more delicate fishes are eaten whole, with the exception of the head.

So far as we have knowledge of the effect of sex upon the nutritive qualities of fish, the male or melter is much preferred, as in the herring and salmon. In spring the male only of the lump-fish or cock-padle, Cyclopterus lumpus, is eaten.[2] Later in the year the female is nearly of equal quality.

Castration.

The castration and spaying of fish was at one period practised, but only to a very limited extent, and is now entirely laid aside. It was first performed by Mr Tull of Edmonton, who seems to have been a fishmonger. The earliest notice of his discovery is in the *History of the Royal Academy of Sciences of Paris for* 1742, in the extract from a letter to M. Geoffroy, from Sir Hans Sloane, in which he states that he had seen the operation performed on two small carps. A more detailed account of an improved process was afterwards published in the *Philosophical Trans-*

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[1] Levit. ch. xi. 9, 12.

[2] Neill, *Wernerian Transactions*, vol. i. p. 548.

actions for 1754. Mr Tull's object at first was to prevent the excessive increase of fish in some of his ponds, where the numbers did not permit any of them to grow to an advantageous size; but from castration the increase was not only prevented, but the castrated fish grew much larger than their usual size, were more fat, and, what was no trifling consideration, were always in season. The operation was performed by making a longitudinal incision from between the two fore-fins almost to the anus of the fish, laying aside the intestines, first on one side, and then on the other, and dividing transversely the oviduct or vas deferens. The wound in the integuments was then stitched up, and, without further attention, few fish died of the operation. The operation was most easily performed in May, when the ovaries and spermatic vessels are full. In France Baron de la Tour operated so successfully that out of two hundred carps he did not lose four. It was also tried in Germany, and it was observed that those fish castrated in spring were in autumn still smaller than the others; but that in the following spring they were large and fat, but, some people thought, not so well tasted.[1]

Age of fish.

In regard to the age of fish as affecting their fitness for food, we are inclined to think that the adage "better small fish than none," implying that the larger they are the better, is not always correct; for although a well-grown and well-nourished individual is always finer than one not in so good condition, and although some fishes, naturally soft, may become firmer as they grow older, yet many fishes are certainly more delicate when of a smaller size, probably from being younger. Cod is generally preferred large, but we have seen large cod exceedingly coarse. The haddock is certainly better when it does not exceed a middling size; and the whole skate tribe are apt to get coarse and strong as they get large. Ausonius says the bream is the only animal which improves by old age:

> Tu melior pejore ævo, tibi contigit uni,
> Spirantum ex numero, non inlaudata senectus.

The flavour of fish is very much influenced by the nature of their food, independently of their apparent condition; and hence there is the greatest difference of the fish on different coasts, or in different rivers and lakes. In general, sea-fish are best where the water is deep, and strong or salt, and where the shore is bold and rocky. Hence the cod and ling caught near the shores, estuaries, and bays, are greatly inferior in quality to fish caught off headlands, in strong currents and deep water. Of the river fish, those which are found in clear, rapid streams, with a rocky or gravelly bottom, in a mountainous country, are indeed less fat, but better tasted; and hence the salmon of the Elbe and Rhine are more valued than those of the other continental rivers. The Thames salmon, however, is preferred in the London market to all other, and some epicures pretend to be able to distinguish by the taste when it comes from a favourite reach of the river. Certain, however, it is, that fish caught in slow-running waters, with a muddy bottom, such as occur in flat countries with a rich soil, though generally larger and fatter, are very inferior in the more essential points of flavour and firmness. Also the fish of large deep lakes, with a gravelly bottom, is much preferable to that of small, shallow, and muddy ponds or tanks. The bad qualities of fish in stagnant waters, into which the filth of cities was emptied, did not escape the notice of Galen. Fresh-water fish bred in muddy bottoms or foul water are sometimes freed from the unpleasant earthy taste by keeping them for some time in ponds of clear water with a gravelly bottom.

Season.

The season of the year has the most marked effect upon the quality of fish, as connected with their spawning. In general, fish of every kind are best some time before they begin to spawn, and are unfit for food some time after they have spawned. This, however, is not sufficient to prevent those who have an easy opportunity, from catching and eating fish in this state; and the legislature has found it necessary to fix the periods during which salmon fishing is legal. When the salmon is in the sea, and about to enter the rivers for the purpose of spawning, it is infested with a parasitical insect, which adheres to every part of the body, and dies and drops off after the fish has been for a short time in fresh water. In this state it is in the highest perfection, the flesh is firm, red, and delicious, the form elegant, and the colours beautiful. On first entering the river, the silvery colour of the sides is very slightly marked with spots; but when it has remained long in fresh water this colour decays, and the spots become much larger, darker coloured, and more obvious. At the time of spawning, the sides of the fish get of a very red colour, and when the spawning is over the white colour entirely disappears, the belly becomes livid, and the sides are streaked all over with a sooty or black colour; and in this state the salmon are termed in the acts of parliament red and black fish. The rays of their fins are all at this time jagged or torn, a great part of their scales rubbed off, and their gills infested with parasitical worms. In Ireland, where great freedom is used in destroying salmon during and after spawning season, the eating of the fish at that time has been often, and in many places, found to be productive of much disease and mortality; and the same is probably sometimes the case in Scotland, although not so much observed as to be generally known; but a very marked instance is mentioned by Dr Walker.[2]

Other fish are probably unwholesome after spawning, but they are seldom caught in that state. Young fish, not come to the age of spawning, are in season all the year.

In regard to their *habitat*, or the situation where they live, fishes may be divided into three families: 1*st*, Those which live entirely in salt water, as the cod and herring; 2*d*, those which live entirely in fresh water, as various species of the cyprinus; and, 3*d*, those which live alternately in salt and fresh water, as the salmon and sturgeon. The comparative esculent qualities of each depend upon a great variety of circumstances; but of the last class it may be remarked, that as they enter the rivers for the purpose of spawning, they are in greatest perfection when they are proceeding up the rivers, and are quite out of season when returning to the sea.

Fish seldom undergo any preparation for killing, nor is there any attention paid to the mode of depriving them of life. Most commonly they are killed as soon as caught, and frequently by merely taking them out of the water. Sometimes, when large, the fishermen strike them upon the head, or tear asunder the branchial vessels. The Dutch carry all their fresh fish alive to market, and when any die previous to being sold, they are exposed in a different manner, and at an inferior price. This practice no doubt insures fresh fish, but if certainly fresh, they will be in greater perfection if killed immediately when caught, than preserved alive for any time in an unnatural situation.

Crimp

To improve the quality of fish, they are sometimes subjected to the process called crimping. It has been exa-

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[1] *Account of Mr Samuel Tull's Method of Castrating Fish*, *Philosophical Transactions*, vol. xlviii. 4to, London, 1755, p. 370. Also Krunitz, *Oekonomisch-technicologische Encyclopädie*, 13ter Th. 8vo, Berlin, 1786, p. 491.

[2] *Prize Essays and Transactions of the Highland Society of Scotland*, vol. ii. Edin. 1803. *Essays on the Natural History of Salmon*, by the Reverend Dr Walker, Professor of Nat. Hist. Univers. of Edin. A. Drummond, Esq. and Messrs Mackenzie and Morrison.

Selection of Fish.

mined by Mr Carlisle, to whom we are indebted for the following facts: "Whenever the rigid contractions of death have not taken place, this process may be practised with success. The sea-fish destined for crimping are usually struck on the head when caught, which it is said protracts the term of this capability, and the muscles which retain this property longest are those about the head. Many transverse sections of the muscles being made, and the fish immersed in cold water, the contractions called crimping take place in about five minutes; but if the mass be large, it often requires thirty minutes to complete the process." The crimping of fresh-water fishes is said to require hard water, and the London fishmongers usually employ it. Mr Carlisle found that, by being crimped, the muscles subjected to the process have both their absolute weight and their specific gravity increased; so that it appears that water is absorbed, and condensation takes place.[1] It was also observed that the effect was greater in proportion to the vivaciousness of the fish. From these observations it appears that the object of crimping is first to retard the natural stiffening of the muscles, and then, by the sudden application of cold water, to excite it in the greatest possible degree, by which means it both acquires the desired firmness, and keeps longer. We may also here observe, that rigidity is a certain mark that the fish is perfectly fresh, and has not begun to spoil.

Mollusci.

The *Mollusci* do not furnish a very extensive source of human food, and they are not without danger. Of those without shells, only the *sepiæ* and some *ascideæ* are eaten, but not generally. The limpet, *Patella vulgata*, the periwinkle, *Turbo littoreus*, and welk, *Murex antiquus*, are eaten boiled by the common people in this country; and the *Helix pomatia* is reared and fattened with great care in some cantons of Switzerland, as an article of luxury, and exported pickled. Many other snails are eaten by the poor in various districts, and we do not know that any is absolutely hurtful. The bivalves, in like manner, are generally wholesome, and some of them have long been among the *deliciæ gulosorum*. The Romans sent to Britain for oysters, and the British epicures delight in the *Pholas dactylus* of the Italian shores.

The crustaceous shell-fish of sufficient size are very generally esculent, and some of them are greatly esteemed, and others abundant. These chiefly belong to the family of *Cancer*, and comprehend both short-tailed and long-tailed species; the velvet crab, one of the most esteemed in France; the *C. mœnas*, eaten by the poor in London; *C. pagurus*, the black-toed crab; *C. ruricola*, the land crab of our Transatlantic islands; *C. gammarus*, the lobster; *C. astacus*, the craw-fish; *C. crangon*, the shrimp; and *C. squilla*, the prawn; besides others not known in this country.

Few insects are used in food. The locust is, however, consumed in great quantities, both fresh and salted, so as to afford some compensation for the ravages it commits. The Moors in West Barbary esteem as delicious, honeycomb with the young bees in it; but Mr Jones says that they seemed insipid to his palate, and sometimes gave him the heartburn.

Vegetables.

Although the vegetable kingdom furnishes the human race, even those who eat flesh most freely, with the greater part of their food, yet there are many more exceptions to the fitness for human food in the vegetable than in the animal kingdom, both from mere indigestibility or defect of nutritious qualities, and from being directly deleterious and hurtful. The selection of vegetable food, when we depart from that which is familiar and known, is therefore more difficult, and subject to uncertainty. There is, however, a certain analogy between the action on the animal economy among vegetables which resemble each other in external form, or in their botanical characters. The arrangement, therefore, of vegetables into natural groups or families, is calculated to assist us in judging of the uses, medicinal or esculent, of untried vegetables.[2]

All parts of vegetables are used as food; roots, stalks, or shoots; leaves, flowers, fruits, seeds, and the whole plant. The seeds of the *Cerealia*, the *Gramineæ* of modern botanists, furnish the most important part of our food in almost every climate. Their mucilaginous shoots also support that class of animals hence called graminivorous, whose flesh is most generally eaten; and the abundance of different species in all varieties of climate, and the absolute identity of their nature, is the cause, as De Candolle well observes, that these animals may be transported and naturalized from one end of the world to the other.

PRESERVATION.

As the supply of food is always subject to irregularities, the preservation of the excess obtained at one time to meet the deficiency of another would soon engage the attention of mankind. At first this method would be simple and natural, and derived from a very limited observation; but in the progress of society the wants and occupations of mankind would lead them to invent means by which the more perishable alimentary substances of one season might be reserved for consumption at another, or the superfluous productions of distant countries might be transported to others where they are more needed. The principles of this most important art have been nowhere better explained than in the 45th number of the *Edinburgh Review*, by an eminent vegetable physiologist.

In general, organic substances, as soon as they are deprived of life, begin to undergo certain chemical changes, more or less rapidly, and of different kinds, according to their nature. Although the modes of change, especially in the first stages, are almost as numerous as the substances themselves, yet ultimately they terminate in one or more of the principal kinds of fermentation described by chemists. To each of these, besides the presence of an organic substance capable of undergoing it, several conditions are requisite, of which the principal are a certain temperature, a certain degree of moisture, and the access of air; and it is by obviating or modifying these conditions that we are enabled to prevent or regulate the natural fermentation. The kind of fermentation which substances undergo depends upon their composition, and it may be generally remarked, that those which do not contain a considerable proportion of azote are incapable of the putrefactive fermentation, but pass through the vinous, acetous, and destructive, successively. On the other hand, those which contain a large proportion of azote are capable only of the putrefactive and destructive; but there are many substances containing a small proportion of azote, in which both kinds of fermentation are combined.

Preservation of vegetables.

A great proportion of vegetables are used in a recent state, and, in this case, the sooner after they are gathered the better. Vegetables, in general, should be kept apart; for, if laid in contact, in a very short time they impart their peculiar flavours to each other. Leeks or celery will

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[1] *The Croonian Lectures on Muscular Motion*, by Anthony Carlisle, Esq. F. R. S. *Philosophical Transactions for* 1805, 4to, London, 1805, p. 23.

[2] *Essai sur les Propriétés Médicales des Plantes, comparées avec leurs formes extérieures et leur classification naturelle.* Par M. A. P. De Candolle, 8vo, Paris, 1816.

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quickly spoil a whole basketful of cauliflower or the finer vegetables. Another general rule is, that they should not be kept in water, nor even washed or refreshed by sprinkling them with water, till they are to be used, as the flavour is thereby greatly injured; but if, by having been cut or gathered some time, they have become flaccid, it is absolutely necessary to restore their crispness before cooking them, otherwise they will be tough and unpleasant. This is to be done when the size of the vegetable admits of it, as cauliflower, salad, celery, and the like, by cutting off a piece of the stalk and setting the fresh surface, thus exposed, in water, which will be absorbed; in other cases the whole vegetable must be immersed in water.

Most vegetable substances being more or less succulent, their full proportion of fluids is necessary for their retaining that state of crispness or plumpness which they have when growing. On being cut or gathered, the exhalation from their surfaces continues, while, from the open vessels of the cut surface, there is often great exudation or evaporation, and thus their natural moisture is diminished, and the tender leaves become flaccid, and the thicker masses or roots lose their plumpness. This is not only less pleasant to the eye, but is a real injury to the nutritious powers of the vegetable; for in this flaccid and shrivelled state its fibres are less easily divided in chewing, and the water which exists in vegetable substances, in the form of their respective natural juices, is directly nutritious. The first care in the preservation of succulent vegetables, therefore, is to prevent them from losing their natural moisture. In regard to the tender succulent vegetables this is not altogether possible, because there is a constant exhalation from their surface, while the supply of moisture is cut off. The principle of preserving them, then, is to retard and diminish the exhalation. This is most effectually done by protecting them from the action of the sun's rays, from the air, and from heat. Even growing vegetables become flaccid in a hot sun, because the exhalation is then greater than the supply; and exposure to the sun is absolutely ruinous to all the more delicate vegetables. The operation of heat and air is slower, but similar. Succulent vegetables should therefore be kept in a cool, shady, and damp place. They should also be kept in a heap, and not spread out, which greatly influences their shrivelling. But when accumulated in too large heaps for any length of time, they are injured in another way, by their heating, as it is called, which is the commencement, in them, of a chemical change, or fermentation, which altogether alters their nature. In many cases the chief business is to prevent evaporation. Potatoes, turnips, carrots, and similar roots, intended to be stored up, should never be cleaned from the earth adhering to them, because the little fibres by which it is retained are thus wounded, and the evaporating surface is increased. They should also be wounded as little as possible, and the tops of turnips and carrots should be cut off close to, but above, the root. The next thing to be attended to is to protect them from the action of the air and of frost. This is done by laying them in heaps, burying them in sand or in earth, immersing them in water, or covering them with straw or mats. The action of frost is most destructive, as, if it be considerable, the life of the vegetable is destroyed, and it speedily rots. A less degree of frost induces a singular but hurtful change upon the potato, by converting part of its starch, or mucilage, into sugar. The germination of seeds also converts their starch into sugar, as is exemplified in the malting of barley. But, even after this change has been induced, if the substance be thoroughly dried in a kiln or otherwise, it will still remain a long time without decay.

Fruits.

The maturation of fruits, although not thoroughly examined, seems to be a change of the same kind, that is, sugar is formed at the expense of the other principle of the unripe fruit. The maturation of fruits is intimately connected with a certain species of decay, as exemplified in the firmer fruits. The rotten parts of many pears is remarkably sweet, and the saccharine matter does not begin to be formed in the medlar until its decomposition be far advanced. In other instances, as in the apple, the decayed part is intensely bitter; and the softer juicy fruits grow mouldy and offensive. The art of preserving fruits consists in being able to prevent and retard these changes. A certain proportion of moisture seems to be necessary for their decay; and hence, by careful exsiccation, grapes are converted into raisins, plums into prunes, and figs are dried. But by carefully excluding them from the air, they may even be preserved without dissipating their natural moisture. Thus currants, cherries, and damsons, gathered perfectly dry and sound, may be put into bottles, closed with cork and rosin, and buried in a trench, with the cork downwards. Fine bunches of grapes may also be preserved in bags, by closing the cut end of the stalk with wax, which prevents the escape of moisture; or they may be packed in very dry bran or sand. Some may even be preserved by being kept immersed in water. This is constantly practised in regard to the cranberry, and sometimes succeeds with apples.

The preservation of fruit is in many countries an object of much importance. In some, the great object is to preserve the fruit in as natural a state as possible. This is particularly the case in regard to winter apples, and pears, and grapes. The time for gathering fruits depends upon their exposure, and the manner of gathering them influences their keeping. After having prepared the fruit-room, a fine day is to be chosen, and, if possible, after two or three preceding days of dry weather, and about two in the afternoon, the fruit is to be gathered, and deposited in baskets of a moderate size, taking care that none of it receive any bruise or blemish, for the injured part soon rots and spoils the sound fruit in contact with it. As the summer fruits ripen more quickly after they are pulled, only a few days consumption should be gathered at once, by which means we can enjoy them for a greater length of time. Autumn apples and pears should be gathered eight days before they are ripe; and, indeed, some kinds never become fit for eating on the tree. If they have been necessarily gathered in wet weather, or early in the morning, they should be exposed a day to the sun to dry, and they should on no account be wiped, which rubs off the bloom as it is called, which, when allowed to dry on some fruits, constitutes a natural varnish, closing up the pores, and preventing the evaporation of the juices. They should not be laid in heaps, which causes them to sweat, and undergo a slight fermentation; for fruit thus treated, if it does not spoil, gets dry and mealy; and hence, in this country, the ordinary apples imported from England and the Continent are inferior to our own. The principal requisites for a good fruit-room are great dryness, and equality of temperature, and the power of excluding light. Some curious persons preserve fine pears by passing a thread through the stalk, of which they seal up the end with a drop of sealing-wax, enclose each separately in a cone of paper, and hang them up by the thread brought through the apex. Experience has also proved that grapes keep better when hanging than when laid upon a table. The cut end should be closed with wax, which prevents exhalation. Some hang them by the stalk, others by the point of the bunch, as the grapes are thus less pressed against each other; but it is in both cases necessary to visit them from time to time, and cut off, with a pair of scissors, every berry that is mouldy or spoiled.

More artificial modes of preserving grapes in a succulent state are sometimes used, and become necessary for their transportation to distant countries. They are often packed with bran and saw-dust; and Apicius says they may be preserved in barley. The same classical gourmand was well acquainted with the use of water in preserving the grapes in their natural state. "Take grapes from the vine without wounding them. Boil rain water down to a third, and put it into a vessel, into which you also put the grapes. Close the vessel with pitch and gypsum, and place it in a cool situation, to which the sun has not access, and when you please you will have green grapes. The water may be given to sick persons as hydromel." The boiling of the water so long is unnecessary, as a much shorter time would be sufficient to expel the air, which is probably the manner in which it has some effect. The water will acquire a slight acidity from the grapes; and hence it was given, sweetened with honey, as a pleasant drink to the sick.

Animal substances in general, when deprived of life, have a natural tendency to undergo the putrefactive fermentation. Before this is established they pass through a series of successive changes, which are intimately connected with our subject. After death the bodies of animals cool more or less rapidly, according to the temperature and conducting power of the air, or other substances with which they are in contact. In fact they do not differ in this respect from an equal mass of any other matter, heated artificially to the same temperature, and having the same conducting power. As this, however, is very weak, the bodies of animals cool very slowly after death.

For some time after death the muscular parts of animals continue to suffer contraction, followed by relaxation, when stimulated, as by the point of a needle, or the application of galvanism. But this irritability, or organic contractility as it is termed by some modern physiologists, gradually disappears in the different organs, and commonly in the muscles of the trunk before those of the limbs. It is also observed, that, in the different classes of animals, the duration of the irritability is inversely as the energy of muscular action which they exhibit during life. It is strongest and most durable in animals which are suddenly killed when in high health, and is weak and evanescent in those which die of lingering diseases, or from fatigue.

After the irritability has entirely ceased, the muscles begin to become rigid, first those of the trunk, and then those of the limbs. Its duration is inversely as the time of its commencement; and it is longest of beginning, but is greatest and lasts longest, in those animals which are suddenly killed when in high health. It appears very quickly, and lasts a short time only, in animals which die of exhaustion or from fatigue. In whatever attitude the limbs are placed at its commencement, they continue; and hence butchers take care to dress properly the carcasses of animals while yet supple. For after rigidity has commenced, if the position of the limb be forcibly changed, it is destroyed, and the joint becomes permanently supple. Also muscles which are frozen when rigid, are extremely supple as soon as they are thawed. Rigidity is perhaps never developed in animals frozen to death.[1]

While this rigidity continues, the flesh of animals is hard and stringy, and, so far as the palate is concerned, not yet fit for the table, although fully nutritious, and in perfection for making soup. After the rigidity has totally ceased, animal flesh is not long of experiencing the commencement of those chemical changes which terminate in putrefaction; and it is of the utmost importance, in domestic economy, to take care that all large joints be in this intermediate state when they are cooked; for no skill in the culinary art will compensate for negligence in this point, as every one must have often experienced to his great disappointment. Meat in which we are able to detect the slightest trace of putrescency has reached its greatest degree of tenderness, and should be used without delay; but before this period, which in some kinds of meat is offensive, the degree of inteneration may be known by its yielding readily to the pressure of the finger, and by its opposing little resistance to an attempt to bend the joint. Poultry also thus part readily with their feathers, and it would be advisable to leave a few when the bird is plucked, in order to assist in determining their state. "No man who understands good living will say, on such a day will I eat that turkey; but let him hang it up by four of the large tail feathers, and when, on paying his morning visit to the larder, he finds it lying upon a cloth prepared to receive it when it falls, that day let it be cooked." But as we cannot always choose our time for eating the joints in our larder, we must, in providing them for a particular day, estimate that they will then be in a proper state, or, if necessary, endeavour to hasten or retard it. By experience we acquire some knowledge of the length of time for which the different kinds of meat should be kept, although it is subject to great variations, depending upon the temperature, moisture, and ventilation of the place where it is kept, upon the kind of meat, the age of the animal, and upon peculiarities in the individual not understood.

The chief means of preventing the fermentation of organic substances are, reduction of temperature, desiccation, exclusion of air, and the action of certain substances called antiseptic. Although most commonly employed in combination with each other, we shall briefly explain the principles upon which they act singly, and then notice their practical application in reference to the animal and vegetable kingdoms.

A moderate reduction of temperature acts by retarding vital and chemical action, and a reduction, capable of freezing the juices and fluids of organized bodies, by destroying vitality, and converting the water present into ice, and thus removing a condition essential to chemical action. Many vegetable, and some animal substances, such as eggs, possess what may be called latent life, and so long as this continues they resist fermentation. A very low temperature puts an end to it, while a high temperature calls it into action, after which it cannot be suspended without destroying it altogether, and thus it is longest preserved in a temperature just a little higher than the former. An egg which has been frozen is killed, and rots soon after being thawed. On the other hand, by incubation, or an equal degree of heat, the life of the chick becomes active, and cannot again be checked with impunity; while, at a moderately low temperature, the latent life of an egg continues a great length of time, ready to be excited into action when placed in favourable circumstances, and resisting the natural tendency to chemical change. The same observation nearly applies to vegetables. Succulent roots, for example, can be long preserved in a moderately low temperature; but if it be raised they begin to shoot, or if it be reduced too much they die, and soon rot.

On dead organic substances a reduced temperature acts by retarding or preventing chemical change.

The preservative effects of cold are of the utmost importance to the northern nations, by enabling them to store up a sufficient stock of all manner of provisions for their winter consumption, and to receive supplies from a great distance. It is thus that veal frozen at Archangel is brought to Petersburg, and the markets of Moscow present immense stocks of hogs, sheep, and fish. The same advantage is

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[1] *Recherches de Physiologie et Chimie Pathologiques*, par P. N. Nysten, 8vo, Paris, 1811.

Preservation of Food.

taken of the cold in Canada, and all other countries where the frost is sufficiently steady.

Substances, so long as they are hard frozen, probably undergo no chemical change, of which the most striking proof was afforded by the body of an animal, probably antediluvian, being found imbedded in a mass of ice at the mouth of the Lena; but in the act of freezing, or of the subsequent thawing, some alteration is produced, which affects the nature of the substance. This may be either merely mechanical, from the particles of ice, during their formation, tearing asunder and separating the fibres; or chemical, by destroying the intimate union of the constituents of the fluids, as in wine injured by having been frozen; or by causing new combinations, of which we have an example in the sweetness acquired by the potato.

Captain Scoresby, contrary to popular belief, states that "the most surprising action of the frost on fresh provision is in preserving it a long time from putrefaction, even after it is thawed and returns into a warm climate. I have," says he, "eaten unsalted mutton and beef nearly five months old, which has been constantly exposed to a temperature above the freezing point for four or five weeks in the outset, and occasionally assailed by the septical influences of rain, fog, heat, and electricity, and yet it has proved perfectly sweet. It may be remarked that unsalted meat that has been preserved four or five months in a cold climate, and then brought back to the British coasts during the warmth of summer, must be consumed very speedily after it is cut into, or it will fail in a day or two. It will seldom, indeed, keep sweet after being cooked above twenty or thirty hours."

In freezing animal substances for the purpose of preserving them, no other precaution is necessary than exposing them to a sufficient degree of cold. "Animal substances," says Captain Scoresby, "requisite as food, of all descriptions (fish excepted), may be taken to Greenland and there preserved any length of time, without being smoked, dried, or salted. No preparation of any kind is necessary for their preservation, nor is any other precaution requisite, excepting suspending them in the air when taken on shipboard, shielding them a little from the sun and wet, and immersing them occasionally in sea-water, or throwing sea-water over them after heavy rains, which will effectually prevent putrescency on the outward passage, and in Greenland the cold becomes a sufficient preservation, by freezing them as hard as blocks of wood." "The moisture is well preserved by freezing, a little from the surface only evaporating, so that if cooked when three, four, or five months old, meat will frequently appear as profuse of gravy as if it had been but recently killed." Captain Scoresby has not informed us why fish cannot be taken to Greenland in a frozen state, though this is a mode of preservation much used in Russia and Germany, and even in our own country.

Some attention is necessary for thawing provisions which have been frozen. "When used, the beef cannot be divided but by an axe or a saw; the latter instrument is generally preferred. It is then put into cold water, from which it derives heat by the formation of ice around it, and soon thaws; but if put into hot water, much of the gravy is extracted, and the meat is injured without being thawed more readily. If an attempt be made to cook it before it is thawed, it may be burnt on the outside, while the centre remains raw, or actually in a frozen state." These observations, which we have transcribed from Captain Scoresby,[1] an excellent observer, agree with the directions of earlier writers. Thus Krünitz says, "when fish taken under the ice are frozen, lay them in cold water, which thus draws the ice out of the fish, so that it can be scraped off their scales. They taste much better afterwards than when they are allowed to thaw in a warm room."[2] We do not know whether it be ignorance or inattention to this direction on the part of the London fishmongers which causes the salmon sent from Scotland in ice to be little esteemed.

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The second general method of preventing fermentation is desiccation, or the removal of that degree of moisture which is an essential condition to this kind of chemical action. Desiccation takes place in consequence of the air absorbing the moisture of bodies exposed to its action. It is therefore promoted by the size of surface exposed, by the dry state of the atmosphere, increased temperature, and by the constant change of the air in contact with the body to be dried, or, in other words, by exposing it to a free current of air. This mode of checking fermentation is assisted by dividing or cutting the bodies to be dried, especially across the grain, which acts not only by increasing the surface, but perhaps still more by dividing the vessels containing the moisture or fluids, and thus allowing them to be freely acted upon by the air, to which the skin or epidermis, when entire, frequently exposes a very great obstacle. In pharmacy, where exsiccation is often necessary, this is well understood, and expressed in the collegiate directions for drying squills, and other succulent roots. In domestic economy it is also practised in drying artichoke bottoms, and guarded against when vegetables are required to be kept succulent, which are or ought to be trimmed or wounded as little as possible till they are to be used. Animal substances also dry much more slowly so long as the surface is entire; and hence some country butchers skin veal joint by joint only, as it is required. The influence of extent of surface is a matter of constant observation. A little water, which would require days to evaporate out of a wine glass, disappears in a few minutes when spread over a China plate. Also solid substances dry more quickly in proportion to the smallness of their size, as the surface exposed is proportionably greater. But none of the agents in accelerating exsiccation has so great an influence as the dry state of the air by which it is effected.

Mr Hearne[3] gives an account of the manner in which the Indians of North America preserve, by means of mere exsiccation, the flesh of musk oxen, deer, or any other animal. To prepare meat in this manner, no farther operation is required than cutting the lean parts of the animal into thin slices, and drying it in the sun, or by exposing it to the heat of a fire, when it is reduced to powder by beating it between two stones. Meat prepared in this way is very portable, and always ready for use, and it is very substantial; for Mr Hearne found that he could always travel longer without victuals after making a meal of it, than after any other kind of food. The northern Indians dry their meat by the heat of a very slow fire, or by fastening it to the tops of the women's bundles, and allowing it to dry by the sun and wind as they walk along. But the southern Indians expose it to the heat of a very large fire, which, in Mr Hearne's opinion, exhausts its juices, renders it as hard as horn, and gives it a bitter taste, whereas the other is soft and mellow in the mouth, and entirely free from smoke. Fish is also dried by them in the sun, and pounded for the sake of carriage.

The third general means of preventing fermentation is the total exclusion of atmospheric air, or rather of oxygen.

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[1] See his *Account of the Arctic Regions, with a History and Description of the Northern Whale Fishery*, 2 vols. 8vo, Edinb. 1819.

[2] *Encyclop.* vol. x. p. 586.

[3] *Journey to the Northern Ocean.*

The truth of this is not so obvious to common observation as that of the others; for, on the contrary, we every day see substances spoiled by being apparently excluded from the air, but in reality by being shut up in confined air; and we are taught to consider free ventilation as a powerful means of preservation. The manner in which the latter acts we have shown to be by removing moisture, especially when contaminated by the exhalation of the perishable substance. The *rationale* of the former is more obscure, but has been ingeniously attempted by Gay-Lussac, and the *Edinburgh Review* (No. xlv.), in order to explain the processes of M. Appert. Gay-Lussac found that neither fresh vegetable juices nor animal matter fermented so long as oxygen gas was perfectly excluded; and that the fermentation, in both cases, commenced as soon as any portion of oxygen was admitted. When oxygen gas is confined in contact with a fermentable substance, it is changed into an equal bulk of carbonic acid gas, and all farther action ceases. Methods of preserving fermentable substances, illustrative of this principle, have long been practised imperfectly by housewives. Nothing can be simpler than Mr Raffald's receipt for preserving green peas, cranberries, currants, &c. "Put them into dry clean bottles, cork them close, and tie them with a bladder; keep them in a cool dry place." A variation of this process was to fill the bottles previously with sulphurous acid vapour, by holding in them for some time a lighted sulphur match. One effect of this is to remove all uncombined oxygen. Other methods of excluding air were also employed, as filling up the interstices with water or melted suet. The success of this process was greatly promoted by subjecting the substances to the action of a certain degree of heat, after being put into the bottles or jars in which they were to be preserved; and then we are desired "to set them in a copper of hot water till they are hot quite through," or to "put them in an oven when the bread is drawn, and let them stand till shrunk a quarter part."

In these cases the heat seems to act by coagulating and rendering insoluble and inactive a kind of gluten, which seems to be a principal agent in beginning fermentation. In general, in the old processes, we were directed not to cork or tie up the vessels until they were quite cool, by which it now appears a very great advantage was lost. But Mr Saddington obtained, in 1817, a premium from the Society of Arts for a method of preserving fruit without sugar, for house or sea stores; the chief peculiarity of which consisted in filling the bottles, as soon as they are taken out of the bath, with boiling water to within an inch of the cork, and immediately corking them very tight and laying them on their sides, that the cork may swell and effectually exclude the air. Animal substances have also long been occasionally preserved by the mere exclusion of air. The most familiar example is the buttering of eggs, which has the effect of closing the pores in the shell by which the communication of the embryo with the external air takes place. It is best performed by rubbing over the shell with butter while it is still warm after being laid; and an egg in this way retains the curdy milk, and possesses all the properties of a new-laid egg for a great length of time; but at whatever period after being laid the egg is buttered over, its progress to decay seems to be arrested. The same effect is produced, though not so perfectly, by immersing eggs in water. From an experiment of Reaumur's, it appears that the cutting off the access of air to the embryo in the egg does not kill it or prevent it from being hatched, but, on the contrary, preserves it alive for a much greater time than if it had not been treated in this manner. He covered over eggs with spirit varnish, and he found them capable of producing chickens after two years, when the varnish was carefully removed.

Although, however, the preservation of alimentary matters by the total exclusion of air, assisted by subjecting them to a certain degree of heat, has long been practised in some degree, we are certainly indebted to M. Appert,[1] who first published in 1810, for the regular and scientific application of these principles upon a large scale. From extensive experience and long perseverance he became convinced,

"1*st*, That fire has the peculiar property, not only of changing the combination of the constituent parts of vegetable and animal productions, but also of retarding, for many years at least, if not of destroying, the natural tendency of those same productions to decomposition.

"2*dly*, That the application of fire in a manner variously adapted to various substances, after having, with the utmost care, and as completely as possible, deprived them of all contact with the air, effects a perfect preservation of those same productions, with all their natural qualities."

Upon these principles he invented many processes adapted to the different natures of the substances to be preserved; but the fundamental conditions consist, 1*st*, In enclosing in bottles the substances to be preserved. 2*dly*, In corking the bottles with the utmost care; for it is chiefly on the corking that the success of the process depends. 3*dly*, In submitting these enclosed cases to the action of boiling water in a water-bath (*Balneum Mariæ*), for a greater or less length of time, according to their nature, and in the manner pointed out with respect to each several kind of substance. 4*thly*, In withdrawing the bottles from the water-bath at the period described.

M. Appert employed at first bottles made of glass, which it was difficult to close exactly, especially when their mouths were large; but he now uses cylinders of tin plate, which are soldered up after they are filled. This is especially an improvement for animal substances, which require much more attention than vegetables. Tin cases or canisters seem to have been first used in London by Messrs Donkin and Gamble, by whom a very ingenious method of testing the provisions put up by them was also invented as early as 1813.[2] The substances to be preserved are first parboiled, or somewhat more. The vegetables and meat, the bones being removed, are then put into tin cylinders, which are filled up with the broth, and the lid soldered down. It now undergoes the remainder of the cooking, when a small hole is opened at the top of the cylinder, and immediately closed with solder while still hot. The whole is now allowed to cool, and from the diminution of volume in the contents, in consequence of the reduction of temperature, both ends of the cylinder are pressed inwards and become concave. The cases thus hermetically sealed are exposed in a *test-chamber*, for at least a month, to a temperature above what they are ever likely to encounter; from 90° to 110° Fahrenheit. If the process has failed, putrefaction takes place, and gas is evolved, which in process of time will bulge out both ends of the case, so as to render them convex instead of concave. But the contents of whatever cases stand this test will infallibly keep perfectly sweet and good in any climate, and for any length of time. Another advantage is, that if there be any taint about the meat when put up, it inevitably ferments, and is detected in the proving.

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[1] *Le Livre de tous les Ménages ; ou l'art de conserver pendant plusieurs années toutes les substances animales et végétables*, 3me edit. Paris 1813.

[2] In a patent granted in 1819 to Mr Æneas Morrison of Glasgow, for preserving food upon similar principles, the corks or bungs are perforated by a tin tube, which is hermetically sealed by driving down a tin plug whilst the vessel is still quite hot and filled with steam.

All kinds of alimentary matters may be preserved in this way,—beef, mutton, veal, and poultry, boiled and roasted, soups, broths and vegetables, creams and custards. The testimonies in favour of the success of the process are of the most unexceptionable kind. The meat is put up in canisters of from four pounds to twenty pounds weight each, and the milk and soups in quart or pint bottles. The meat is charged from 1s. 8d. to 3s. a pound; roast higher than boiled, and veal dearer than mutton or beef. The milk is 24s. per dozen for quarts, 15s. for pints, and 10s. for half pints; and soups from 30s. to 60s. per dozen for quarts. The weight of the canister is deducted, and nothing is charged for canisters or bottles; and it should be observed, that the patent provisions being cooked, and without bone, render them nearly equivalent to double the weight of meat in the raw state; for, by experiment, the patentees found, that the waste in cooking, and weight of bone, are about one half. Captain Neish took a quantity to India; not one canister spoiled; and one which he brought home contained beef in the highest state of preservation after two years, and having been carried upwards of 35,000 miles in the warmest climates. The commissioners for victualling the navy also examined some nearly four years old, which had been in the Mediterranean and Quebec, and found it as sound, sweet, and fresh, as if it had been only yesterday boiled. We are also enabled to add the testimony of Captain Basil Hall, who has liberally communicated to us the result of his personal experience and observation: "I can answer for the perfect preservation of a great number of cases which were in my possession during the voyage to China. I had L.88 worth, and not one failure. At that time milk was preserved in bottles corked; but tin cases have been substituted with very great effect, as I have myself tried. It is really astonishing how excellent the milk is; and, indeed, every thing preserved in this way is good.

"You must, on examining the lists of prices, bear in mind that meat thus preserved *eats* nothing, nor *drinks*—is not apt to get the rot, or to die—does not *tumble* over board, nor get its legs broken or its flesh worn off its bones by knocking about the decks of a ship in bad weather—it takes no care in the keeping—it is always ready, may be eat cold or hot, and thus enables you to toss into a boat in a minute as many days' *cooked* provisions as you choose—it is not exposed to the vicissitudes of markets, nor is it scourged up to a monstrous price, as at St Helena, because there is no alternative. Besides these advantages, it enables one to indulge in a number of luxuries which no care or expense *could* procure."

The property of salt to preserve animal substances from putrefaction is of most essential importance to the empire in general, and to the remote grazing districts in particular. It enables the latter to dispose of their live stock, and distant navigation is wholly dependent upon it. All kinds of animal substances may be preserved by salt, but beef and pork are the only staple articles of this kind. In general, the pieces of the animal best fitted for being salted are those which contain fewest large blood-vessels, and are most solid. Some recommend all the glands to be cut out, and say, that without this precaution meat cannot be preserved; but that this is a mistake, the salt udder, and glands of the tongue, every day's experience shows.

The salting may be performed either by dry rubbing, or by immersing the meat in pickle. Cured in the former way the meat will keep longer, but it is more altered in its valuable properties; in the latter way it is more delicate and nutritious. Six pounds of salt, one pound of sugar, and four ounces of saltpetre, boiled with four gallons of water, skimmed and allowed to cool, forms a very strong pickle, which will preserve any meat completely immersed in it. To effect this, which is essential, either a heavy board, or flat stone, must be laid upon the meat. The same pickle may be used repeatedly, provided it be boiled up occasionally with additional salt to restore its strength, diminished by the combination of part of the salt with the meat, and by the dilution of the pickle by the juices of the meat extracted. By boiling, the albumen, which would cause the pickle to spoil, is coagulated, and rises in the form of scum, which must be carefully removed.

Dry salting is performed by rubbing the surface of the meat all over with salt; and it is generally believed that the process of salting is promoted if the salt be rubbed in with a heavy hand. On the contrary, it is said, that in very hot countries, for example, Jamaica, where it is so necessary that the action of the salt should take place as quickly as possible, the mode of salting a round of beef is to place it on two sticks over a tub of water, with the small end uppermost, and to cover it with a heap of salt, which penetrates through the veins and arteries, and among the fibres, in the state of a saturated solution. However this may be, it is almost certain that very little salt penetrates, except through the cut surfaces, to which it should therefore be chiefly applied; and all holes, whether natural or artificial, should be particularly attended to. For each twenty-five pounds of meat, about a pound of coarse-grained salt (St Ubes' is the best) should be allowed, and the whole, previously heated, rubbed in at once. When laid in the pickling tub, a brine is soon formed by the salt dissolved in the juice of the meat which it extracts, and with this the meat should be rubbed every day, and a different side turned down. In ten or twelve days it will be sufficiently cured.

For domestic use, the meat should not be salted as soon as it comes from the market, but kept until its fibre has become short and tender, as these changes do not take place after it has been acted upon by the salt. But in the provision trade, "the expedition with which the animals are slaughtered, the meat cut up and salted, and afterwards packed, is astonishing."[1] By salting the meat while still warm, and before the fluids are coagulated, the salt penetrates immediately, by means of the vessels, through the whole substance of the meat; and hence meat is admirably cured at Tunis, even in the hottest season; so that Mr Jackson, in his *Reflections on the Trade of the Mediterranean*, recommends ships being supplied there with their provisions.

"Take half a pound of black pepper, half a pound of red or kyan pepper, and half a pound of the best saltpetre, all beat or ground very fine; mix these three well together, then mix them with about three quarts of very fine salt: this mixture is sufficient for eight hundredweight of beef. As the pieces are brought from the person cutting up, first sprinkle the pieces with the spice, and introduce a little into all the thickest parts; if it cannot be done otherwise, make a small incision with a knife. The first salter, after rubbing salt and spice well into the meat, should take and mould the piece, the same as washing a shirt upon a board; this may be very easily done, and the meat being lately killed, is soft and pliable; this moulding opens the grain of the meat, which will make it imbibe the spice and salt much quicker than the common method of salting. The first salter hands his piece over to the second salter, who moulds and rubs the salt well into the meat, and, if he observes occasion, introduces the spice; when the second salter has finished his piece, he folds it up as close as possible, and hands it to the packer at the harness tubs, who must be stationed near him: the packer must be careful to pack his harness tubs as close as possible.

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[1] Wakefield's *Ireland*, vol. i. p. 750.

"All the work must be carried on in the shade, but, where there is a strong current of air, the harness tubs in particular; this being a very material point in curing the meat in a hot climate. Meat may be cured in this manner with the greatest safety when the thermometer, in the shade, is at 110°, the extreme heat assisting the curing.

"A good sized bullock, of six or seven hundredweight, may be killed and salted within the hour.

"The person who attends with the spice near the first salter has the greatest trust imposed upon him; besides the spice, he should be well satisfied that the piece is sufficiently salted before he permits the first salter to hand the piece over to the second salter.

"All the salt should be very fine, and the packer, besides sprinkling the bottom of his harness tubs, should be careful to put plenty of salt between each tier of meat, which is very soon turned into the finest pickle. The pickle will nearly cover the meat as fast as the packer can stow it away. It is always a good sign that the meat is very safe when the packer begins to complain that his hands are aching with cold.

"By this method, there is no doubt but that the meat is perfectly cured in three hours from the time of killing the bullock. The saltpetre in a very little time strikes through the meat: however, it is always better to let it lie in the harness tubs till the following morning, when it will have an exceeding pleasant smell on opening the harness tubs; then take it out and pack it in tight barrels, with its own pickle."

Beef and pork, in a less degree, properly salted with salt alone, acquire a green colour; but if an ounce of saltpetre be added to each five pounds of salt employed, the muscular fibre acquires a fine red colour; but this improvement in appearance is more than compensated by its becoming harder and harsher to the taste; to correct which, a proportion of sugar or molasses is often added. But the red colour may be given if desired, without hardening the meat, by the addition of a little cochineal.

Meat, when salted, is either preserved immersed in pickle, in close vessels, or dried, when it gets the name of bacon, ham, or hung beef.

Meat kept immersed in pickle rather gains weight. In one experiment by Messrs Donkin and Gamble, there was a gain of three per cent., and in another of two and a half; but in the common way of salting, when the meat is not immersed in pickle, there is a loss of about one pound or one and a half in sixteen.

The drying of salt meat is effected either by hanging it in a dry and well-aired place, or by exposing it at the same time to wood smoke, which gives it a peculiar flavour, much admired in Westphalia hams and Hamburg beef, and also, perhaps, tends to preserve it, by the antiseptic action of the pyrolignic acid. When meat is to be hung, it need not be so highly salted.

Fish, in like manner, may be preserved either by dry salting or in pickle. The former method is employed to a great extent on the banks of Newfoundland and in Shetland. For information on this important subject, the article FISHERY may be consulted.

Dr Hibbert thinks that the cod-fish prepared in Shetland will always maintain its pre-eminence over the cod of other places. In Newfoundland the fish are said to be exposed, after being salted, on standing flakes, made by a slight wattle, and supported by poles, often twenty feet from the ground. But the humidity is not nearly so well extracted from the fish as when, according to the Shetland method, they are carefully laid out upon dry beaches, the stones of which have been during winter exposed to the abrading action of the ocean, and are thus cleared from animal and vegetable matter.[1]

The Dutch derive great national advantages from the preference given to the herrings caught upon our own coasts, when cured by them. They use no other than the Spanish or Portuguese salt, preserve no fish that they are not able to cure between sunrise, when the nets are drawn, and sunset, when they are again shot, and pay particular attention in giping, sorting, and packing each kind by itself. They fill up the barrels with fish of the same kind and night's catching, and are exceedingly careful of the pickle, as they use no other in filling of the barrels.[2]

Herrings and salmon are also often cured by drying them in wood smoke after being slightly salted, and are called red herrings or Yarmouth herrings, and kipper or smoked salmon.

Butter is commonly preserved by working into each pound one or two ounces of salt, until they be thoroughly incorporated. The best salt for the purpose is in large crystals, and it should be thoroughly dried and coarsely powdered. But Dr Anderson recommends for the curing of butter, a mixture of two parts of the best great salt, one of sugar, and one of saltpetre, beat into a fine powder. One ounce of this mixture is sufficient for a pound of butter. He says that butter cured in this way does not taste well till it has stood at least a fortnight after being salted; but after that period it has a rich marrowy taste, that no other butter ever acquires, and tastes so little salt, that one would imagine it would not keep; and yet Dr Anderson has seen it perfectly sound and sweet when two years old.

Butter spoils and becomes rancid, chiefly from the milk, which is not entirely expressed from it, and in consequence of the albumen, which is constantly present. These may be separated by melting the butter and keeping it over the fire until all the water be evaporated, when the albumen will also be coagulated, and sink to the bottom. To prevent all risk of producing an empyreumatic taste, the vessel containing the butter should not be exposed directly to the fire, but placed in a larger vessel filled with water, which is made to boil, forming what the chemists call a water-bath. While the butter remains fluid, it resembles a perfectly transparent oil, and on cooling it becomes opaque, and is firmer and a little paler than the butter before it was clarified. It will keep for a considerable time without salt; but if it be salted as common butter, it will continue much longer sweet in hot climates, than if it had been cured in its original state.[3]

The natives of Hindustan never use butter, but prefer what is called *ghee*, because it keeps better, and has more taste and smell. Their butter is prepared from coagulated acid milk; and in order to collect a sufficient quantity, it is often kept two or three days, by which time it is highly rancid. It is melted in an earthen pot, and boiled until all the water be evaporated. After being taken from the fire, a little coagulated acid milk and salt, or betel leaf and reddle, are added. It is kept in pots, and eaten when even a year old.[4]

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[1] *Edinburgh Philosophical Journal*, No. iii. p. 148.

[2] *Highland Society's Transactions*, vol. ii. p. 321.

[3] Anderson's *Recreations*, vol. iv. p. 87.

[4] Buchanan's *Journey from Madras*, vol. ii. p. 15.

Preservation of Food.

Vinegar, in itself a very destructible substance when exposed to the air, tends greatly to preserve vegetable substances when both are carefully excluded from it. In general, however, the vegetable is previously salted. After the pickles are prepared, the bottles are to be carefully corked, tied up with bladder, and sealed over with wax or rosin. For the making of pickles, the vinegar now distilled from wood, as in itself containing no principles of decay, must be preferable to common vinegar.

M. Parmentier has given a minute description of the process of making sour krout on the great scale. The heads of winter cabbages, after removing the outer leaves, are to be cut into fine shreds, by means of an instrument made on purpose, and then spread out to dry upon a cloth in the shade. A cask is to be set on end, with the head taken out. If it formerly contained vinegar or wine, so much the better, as it will promote the fermentation, and give the cabbage a more vinous taste; if not, the inside may be rubbed over with some krout barm. Caraway seeds are to be mixed with the shreds of cabbage, a good layer of salt placed at the bottom of the cask, and then cabbage shreds to be evenly packed, to the depth of six inches. A man having on strong boots, well washed and nicely clean, must now get into the cask, and tread down the shreds to half their original bulk. The same process is to be repeated, with additional layers of salt and shreds, till the whole be packed. They are then to be covered with a layer of salt, or till the barrel be filled within two inches of the top, over which the outside leaves of the cabbages are to be spread. About two pounds of salt are required for twenty cabbages.

The head of the barrel, which should have been previously well fastened together, is lastly to be put within the barrel above the leaves, and loaded with stones, to prevent the mixture from rising during the fermentation. The mass thus compressed subsides, and the cabbages give out their juice, which rises to the surface, is green, muddy, and fetid. It is to be drawn off by a spigot placed two or three inches down, and replaced by fresh brine every day, until it come off clear, which will take twelve or fifteen days, according to the temperature of the place. The essential point for keeping sour krout good, is to take care that it be always covered at least an inch with pickle. For home consumption enough may be made at one time to serve the year, and the pickle is then renewed at the beginning of spring, and at midsummer. When intended as ship provision for long voyages, the sour krout must be repacked very firmly into other casks, which are then to be filled with fresh pickle, and closed as accurately as possible. When well made and preserved, it has a very pleasant acidity, and is not only very healthy, but agrees with many persons who cannot use fresh cabbages. It is also considered to be a very excellent antiscorbutic; and Captain Cook attributed his success in preserving the health of his crew in his voyage partly to its use.

Vinegar is never used for the preservation of butcher meat, but salmon is often pickled in it, with the addition of salt and spices.

Pryolignic acid has lately been much extolled, as having a specific power in preserving animal matters. It consists of acetic acid, impregnated with an empyreumatic oil. The acid is in general very strong, and being free from the mucilage which promotes the spoiling of common vinegar, it is so far a better antiseptic; but the empyreumatic oil may also add to its powers, either by keeping away insects, to which it is very offensive, or by a direct antiseptic power not understood. Professor Jörg of Leipsic is said to have recovered tainted flesh by rubbing it with the oil separated from the acid; and there is no doubt that the smoking of beef, hams, salmon, and herrings, makes them keep longer than the mere drying, and the degree of previous salting, would lead us to expect.

Sugar has also the power of preserving vegetable substances from decay, but, on account of its expense, it is only used for fine fruits and aromatic substances. The preservation of these by means of sugar constitutes a principal part of the art of confectionary, and attention to many minutiæ is necessary for the success of each preparation. The most general principles only can be noticed here.

Vegetable substances may be either preserved in syrup or candied; or their juices may be employed in making syrups, jellies, or fruit-cakes. The art of confectionary is very difficult, and, to attain perfect success, requires attention to many particulars, which at first seem frivolous and even improper, but which have been found by experience to be essential. The clarification and boiling of the sugar to its proper degree is of primary importance, and has not perhaps been sufficiently examined by scientific men.

A weak syrup has a tendency to ferment, and quickly becomes sour if kept in a temperate degree of heat; it is therefore not calculated to prevent the natural fermentation of vegetable juices, which always increase its tendency to corrupt. Pharmaceutists have ascertained that a solution, prepared by dissolving two parts of double-refined sugar in one of water, or any watery fluid, and boiling the solution a little, forms a syrup, which neither ferments nor crystallizes; and the proportion may be considered as the basis of all syrups, and seems to be the degree of boiling syrup called smooth by the confectioners, as exemplified in their *Syrops de Capillaire, Orgeat*, and others.

Sugar is equally powerful in preserving animal substances from putrefaction. As a novelty to modern artists, we translate from their great precursor, Cælius Apicius, a method of preserving meat at any time without salt: "Let fresh meat of any kind be covered with honey; but hang up the vessel, and use it when you please. This succeeds better in winter; but will last a few days in summer. The same may be done with meat that has been cooked."

Other methods of preserving food have been tried, but rather as a matter of curiosity than utility.

The property of charcoal to restore sweetness to flesh beginning to be tainted, was first pointed out by M. Lowitz in Petersburg, in 1786,[1] who made numerous experiments upon the subject. For their success, it is necessary that the charcoal have been recently burnt, and that it be applied in a certain quantity. Too little fails in its effect, and too much affects the nature of the substance upon which it acts. By some it has been supposed to act merely mechanically, by absorbing fluid and putrescent exudations; but it is more probable that it acts chemically, by absorbing oxygen gas from the air in contact with the meat. In the fourth volume of the *Journal of Science* (p. 367), there is an account of some successful experiments, in which alternate layers of meat and charcoal were packed in canisters, previously filled with carbonic gas, and then carefully luted up and covered with bladder.

In the *Journal de Pharmacie* for September 1818, M. Raymond, professor of chemistry at Lyons, has related some experiments which he made upon the antiseptic properties of chlorine. Beef exposed to the action of this gas for a few minutes underwent no change in the course of six months, except becoming dry from the action of air and time. A Guinea pig, suffocated in the same gas, and afterwards immersed for a few minutes in water saturated with chlorine, and then exposed to the air for four months, without having its entrails removed, showed no sign of putrefaction in four months. He also found that tainted meat recovered the smell and appearance of fresh meat by being immersed in liquid chlorine.

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[1] Crell's *Annals*.

PREPARATION.

Alimentary matters are used either in their crude or raw state, or after having undergone some kind of preparation.

Fruits and salads, although they admit of various forms of cookery, are most frequently eaten in as fresh and natural a state as possible.

Cookery is either necessary to destroy some deleterious property, or to render food more palatable and nutritious. Of the former effect the most remarkable example is furnished by various species of *arum*, which in their crude state are acrid, or even poisonous, but by being cooked become mild and wholesome. The acrimony resides in a very volatile principle, which is easily dissipated by heat. A more familiar example in this country is furnished by the onion tribe, the acrimony and flavour of which are entirely destroyed by being long subjected to the action of heat.

Numerous as the receipts are, the processes of cookery are but few. In some, the chief object is to extract the fluid or soluble parts of the substance cooked; in others, to alter the nature of the substance itself, and often to combine both purposes. Fire is a principal agent in almost all the processes of cookery, and the most economical mode of applying it has engaged the attention of many philosophers and artists.[1]

Convenience and economy are the objects proposed by all alleged improvements. The nature of the fuel is of no little importance, and is different in different countries. Pit coal has the advantage of forming a lasting fire, and producing an intense degree of heat, which renders it almost indispensable for roasting; but its smoke is very detrimental, both by the unpleasant flavour it imparts, and by the inconvenience arising from the flame, and from the soot deposited upon the vessels and in the chimney. Wood and turf evolve less smoke, but their flavour is more penetrating, and they give less heat, and are less durable. The cleanest and most generally useful fuel is charcoal of wood, or coke, neither giving out any smoke, or imparting any flavour. Charcoal is more easily kindled, but coke lasts longer, and gives out more heat. Well burnt cinders are an excellent substitute for coke, which in every family ought to be carefully preserved for the purposes of cookery.

The heat, from whatever fuel produced, is applied in various ways to the substances to be cooked, either directly or indirectly. Heat is applied directly, as radiant heat in the process of roasting, in which the effects are produced entirely by the rays of heat impinging directly upon substances placed at a short distance before it. For this purpose a clear glowing fire is necessary, and the bars of a good roasting grate should impede as little as possible the radiation of its heat. Another very direct mode of applying heat, is by placing the substance over the fire by suspending it in the stream of heated air ascending from it, or laying it directly on the burning fuel, or on bars, or a plate of iron, or other substance capable of supporting the heat. Broiling is the result of this mode of applying heat. Heat is also often applied through the intervention of fluids, chiefly of water or steam, as in boiling or stewing; or of some oily substance, as in frying. The peculiarity of baking consists in the substance being heated in a confined space, which does not permit the escape of the fumes arising from it.

To understand the theory of cookery, we must attend to the action of heat upon the various constituents of alimentary substances, as applied directly and indirectly through the medium of some fluid. In the former way, as exemplified in the processes of roasting and broiling, the chief constituents of animal substances undergo the following changes: the fibrine is corrugated, the albumen coagulated, the gelatine and osmazome rendered more soluble in water, the fat liquefied, and the water evaporated. If the heat exceed a certain degree, the surface becomes first brown, and then scorched. In consequence of these changes, the muscular fibre becomes opaque, shorter, firmer, and drier; the tendons less opaque, softer, and gluey; the fat is either melted out, or rendered semitransparent. Animal fluids become more transparent; the albumen is coagulated and separated, and they dissolve gelatine and osmazome. Lastly, and what is the most important change, and the immediate object of all cookery, the meat loses the vapid nauseous smell and taste peculiar to its raw state, and it becomes savoury and grateful. Heat applied through the intervention of boiling oil or melted fat, as in frying, produces nearly the same changes, as the heat is sufficient to evaporate the water, and to induce a degree of scorching. But when water is the medium through which heat is applied, as in boiling, stewing, and baking, the effects are somewhat different, as the heat never exceeds 212°, which is not sufficient to commence the process of browning or decomposition, and the soluble constituents are removed by being dissolved in the water, forming soup or broth; or, if the direct contact of the water be prevented, they are dissolved in the juices of the meat, and separate in the form of gravy.

It is evident, that whether the heat be applied directly or indirectly, there must be a considerable loss in the cooking of animal substances in public institutions, where the allowance of meat is generally weighed out in its raw state, and includes bones, and is served out cooked, and sometimes without bone; and it is a matter of importance to ascertain nearly their relative proportions. Much, no doubt, depends upon the piece of the meat cooked, and the degree of cookery, and the attention bestowed upon it. We have been informed by persons who salt rounds of beef to sell by retail after they are boiled, that they are able to get 19 lb. of cold boiled beef from 25 lb. raw; but the meat, it must be confessed, is always rather under-done. Messrs Donkin and Gamble boiled in steam 56 lb. of Captain's salt beef; the meat, when cold, without the bones, which amounted to 5 lb. 6 oz. weighed only 35 lb. In another experiment, 113 lb. of prime mess beef gave 9 lb. 10 oz. of bones, and 47 lb. 8 oz. meat; and in a third, 213 lb. mess beef gave 13 lb. 8 oz. bones, and 103 lb. 10 oz. meat; or, taken in the aggregate, 372 lb. of salt beef, including bones, furnish, when boiled, 186 lb. 2 oz. without bone, being about 50 per cent.; or, disregarding the bone altogether, salt meat loses, by boiling, about 44·2 per cwt. We are indebted to Professor Wallace, of the University of Edinburgh, for the detail of a very accurate and extensive experiment in a public establishment, of which the results were, that, in pieces of 10 lbs. weight, each 100 lbs. of beef lost, on an average, by boiling, 26·4; baking, 30·2; and roasting, 32·2: mutton, the leg, by boiling, 21·4; by roasting, the shoulder 31·1, the neck 32·4, the loin 35·9. Hence, generally speaking, mutton loses, by boiling, about one fifth of its original weight, and beef about one fourth; again, mutton and beef lose, by roasting, about one third of their original weight.

The loss arises in roasting from the melting out of the fat and evaporating the water, but the nutritious matters remain condensed in the cooked solid; but in boiling, the loss arises partly from fat melted out, but chiefly from gelatine and osmazome dissolved in the water in which the meat is boiled; there is therefore a real loss of nourishment unless the broth be used, when this mode of cooking becomes the most economical.

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[1] See Rumford's *Essays*; Fournier, *sur les Substances Alimentaires*; *Repertory of Arts*; *Archives des Découvertes*.

Vegetable substances are most commonly boiled or baked; or, if apparently fried or roasted, there is always much water present, which prevents the greater action of the fire from penetrating below the surface. The universal effect of cookery upon vegetable substances, is to dissolve in the water some of their constituents, such as the mucilage and starch, and to render those that are not properly soluble, as the gluten and fibre, softer and more pulpy.

We cannot pretend to enter into the details of the various processes, nor explain the many precautions requisite to ensure success. For practical receipts we recommend *L'Art de Cuisinier*, par A. Beauvilliers; *A New System of Domestic Cookery*, by a Lady; and, lastly and chiefly, *Apicius Redivivus, or the Cook's Oracle*, in which, along with the plainest directions, there is more of the philosophy, and, if we may so speak, of the literature, of *gastronomie*, than in any work we have seen. The reader is also referred to a very curious volume by Mr Accum, on *Adulterations of Food*, and to a German work on the same interesting subject by Knoblauch. The unprecedented success of the *Almanach des Gourmands*, and of the *Manuel des Amphytrions*, shows how much may be made of the subject by a man of talents; nor do the writings of M. Grimod de la Reynière surpass in wit the entertaining articles in the *Edinburgh Review*, No. xi. and in the *Quarterly Review*, No. xlv. (Z.)

FOOSHT, an island in the Red Sea, situated, according to the observations of Mr Bruce, in lat. 13. 59. 43. N. It is described by him as about five miles in length from north to south; and it is low and sandy in the southern part, but in the north rises a black hill of inconsiderable height.

FOOT, a part of the body of certain animals, on which they stand, walk, or run. See ANATOMY.

FOOT, in the Latin and Greek poetry, a metre or measure, which is composed of a certain number of long and short syllables.

Of metrical feet, which are commonly reckoned twenty-eight, some are simple, consisting of two or three syllables, and therefore called *dissyllabic* or *trisyllabic feet;* and others are compound, consisting of four syllables, from which circumstance they are called *tetrasyllabic feet.*

The dissyllabic feet are four in number; the pyrrichius, spondeus, iambus, and trocheus. The trisyllabic feet are eight in number; the dactylus, anapæstus, tribrachys, molossus, amphibrachys, amphimacer, bacchius, and antibacchius. The tetrasyllabic are sixteen in number; the procelcusmaticus, dispondeus, choriambus, antispastus, diambus, dichoreus, ionicus a majore, ionicus a minore, epitritus primus, epitritus secundus, epitritus tertius, epitritus quartus, pæon primus, pæon secundus, pæon tertius, and pæon quartus.

FOOT is also a long measure consisting of twelve inches. Geometricians divide the foot into ten digits, and the digit again into ten lines.

FOOT Square is the same measure both in breadth and length, containing 144 square superficial inches.

Cubic or *Solid FOOT*, is the same measure in all the three dimensions of length, breadth, and depth or thickness, containing 1728 cubic inches.

FOOTE, SAMUEL, was born at Truro, in Cornwall, and descended from an ancient and respectable family. His father was member of parliament for Tiverton in Devonshire, and enjoyed the post of commissioner of the prize office; his mother was heiress of the Dinely and Goodere families. Foote was educated at Worcester College, Oxford, which owed its foundation to Sir Thomas Cookes Windford. On leaving the university he commenced student of law in the Temple; but as the dryness of this study did not suit the liveliness of his genius, he soon relinquished it. He then married a young lady of a good family and some fortune; but their tempers not agreeing, harmony did not long subsist between them. He now launched into all the fashionable follies of the age, gambling not excepted, and in a few years squandered away his whole fortune. His necessities led him to the stage, and he made his first appearance in the character of Othello. He next performed Fondlewife with much greater applause; and this, indeed, was ever afterwards one of his capital parts. He likewise attempted Lord Foppington, but afterwards gave it up as unsuitable to his talents. In 1747 he opened the little theatre in the Haymarket, taking upon himself the double character of author and performer; and he appeared in a dramatic piece of his own composition, called the *Diversions of the Morning*. The piece consisted of nothing more than the exhibition of several characters well known in real life, whose style and manner of conversation and expression the author had very happily hit off in the diction of his drama, and still more happily represented on the stage, by an exact and indeed amazing imitation, not only of the manner and tone of voice, but even of the very persons of those whom he intended to take off. This performance at first met with some opposition from the civil magistrates of Westminster, under the sanction of the act of parliament for limiting the number of playhouses, as well as from the jealousy of one of the managers of Drury Lane theatre. But the author being patronized by many of the principal nobility, and other persons of distinction, this opposition was overruled; and having altered the title of his performance, Mr Foote proceeded, without further molestation, to give *Tea in a Morning* to his friends, and represented it through a run of forty mornings to crowded and splendid audiences. In the ensuing season he produced another piece of the same kind, which he called *An Auction of Pictures*. Into this performance he introduced several new and popular characters; particularly Sir Thomas de Veil, then the acting justice of peace for Westminster, Mr Cock the celebrated auctioneer, and the equally famous Orator Henley. The *Auction* had also a very great run. His *Knights*, which was the production of the ensuing season, exhibited somewhat more of dramatic regularity. But still, although his plot and characters seemed less immediately personal, it was apparent that in the performance he kept some real persons strongly in his eye; and the town took it upon themselves to fix these where the resemblances appeared most striking. Thus Mr Foote continued from time to time to select, for the entertainment of the town, such public characters as seemed most likely to engage their attention. But his dramatic pieces, exclusively of the interlude called *Piety in Pattens*, are only to be ranked among the *petites pièces* of the theatre. In the execution they are somewhat loose, negligent, and unfinished; the plots are often irregular, and the catastrophes frequently inconclusive; but, with all these deficiencies, they contain more strength of character, more strokes of keen satire, and more touches of temporary humour, than are to be found in the writings of any other modern dramatist. Even the language spoken by his characters, incorrect as it may sometimes seem, will on a closer examination be found altogether dramatical: abounding with those natural minutiæ of expression which frequently form the very basis of character, and which render it the truest mirror of the conversation of the times to which it applies.

In the year 1766, being on a party of pleasure with the Duke of York, Lord Mexborough, and Sir Francis Delaval, Mr Foote had the misfortune to break his leg by a fall from his horse, in consequence of which he was compelled to undergo an amputation. This accident so sensibly affected the duke, that he made a point of obtaining for Mr Foote a patent for life, by which he was allowed to perform, at the little theatre in the Haymarket, from the 15th of May to the 15th of September every year.

Mr Foote, finding his health declining, entered into an agreement with Mr Colman, for his patent of the theatre, according to which he was to receive from Mr Colman L.1600 per annum, besides a stipulated sum whenever he chose to perform. Mr Foote made his appearance two or three times in some of the most admired characters; but being suddenly affected with a paralytic stroke one night whilst upon the stage, he was compelled to retire. He was advised to bathe; and accordingly retired to Brighton, where he apparently recovered his former health and spirits, and continued what is called the cock of the company who resorted to that agreeable place of amusement. A few weeks before his death he returned to London; but, by the advice of his physicians, set out with an intention to spend the winter at Paris and in the south of France. He had got no farther than Dover, when he was suddenly attacked by another stroke of the palsy, which in a few hours terminated his existence. He died on the 21st of October 1777, in the fifty-sixth year of his age, and was privately interred in the cloisters of Westminster Abbey. Foote's published dramas, twenty in number, were written in the following order: 1. Taste, a comedy, in 1752; 2. The Englishman in Paris, 1753; 3. The Knights, 1754; 4. The Englishman returned from Paris, 1756; 5. The Author, 1757; 6. The Minor, 1760; 7. The Lyar, 1761; 8. The Orators, 1762; 9. The Mayor of Garrat, 1763; 10. The Patron, 1764; 11. The Commissary; 12. Prelude on opening the Theatre, 1767; 13. The Devil upon Two Sticks, 1768; 14. The Lame Lover, 1770; 15. The Maid of Bath, 1771; 16. The Nabob, 1772; 17. The Bankrupt, 1772; 18. The Cozeners, 1774; 19. A Trip to Calais, 1776; 20. The Capuchin, altered from the former, but prohibited. *Piety in Pattens*, and *The Diversions of a Morning*, altered from *Taste*, were never published. The anonymous mock tragedy entitled *The Tailors* is usually printed with Foote's works, being generally thought to be his composition. Foote borrowed liberally from Molière and others; but what he took without ceremony he generally contrived to make his own by a certain originality in the manner of employing it; and his own humour was so peculiar and effective, that no player has since been equally successful in the parts which he himself performed.

FOP, probably derived from the *vappa* of Horace, applied in the first satire of his first book to the wild and extravagant Nævius, is used amongst us to denote a person who cultivates to excess a regard to adventitious ornament and beauty.

FORAGE, in the military art, denotes hay, oats, barley, wheat, grass, clover, and the like, brought into the camp by the troopers for the sustenance of their horses.

FORBES, DUNCAN, an eminent Scottish lawyer, and Lord President of the Court of Session, was born at Culloden, Inverness-shire, in the year 1685. His natural disposition inclined him to the army; but, as he early discovered a superior genius, he was induced by the advice of friends to apply himself to learning. Having completed his studies at the university of Edinburgh, he removed thence to Utrecht, and afterwards to Paris, where he directed his attention particularly to the civil law, in which he made great progress. He returned to Scotland in 1710, and was the same year called to the bar, where his abilities soon attracted notice, and procured him extensive practice. In 1717 he was appointed solicitor-general of Scotland; in 1722 he was returned member of parliament for the county of Inverness; in 1725 he was made King's Advocate; and in 1742 he attained the highest judicial dignity in Scotland, that of Lord President of the Court of Session. During the rebellion in 1745 and 1746, he was mainly instrumental in preventing a general rising of the Highlanders in favour of the pretender to the crown, and he even mortgaged his estate in support of the government. But the glory he acquired in checking the spread of the insurrection, by preventing some of the most powerful chiefs from joining the standard of Prince Charles Edward, and in afterwards contributing to re-establish peace and order, was the only reward of his services. Although he had impaired, nay almost ruined, his private fortune in the cause of the public, government declined to make him the smallest recompense. The minister of the day, with the meanness for which it is difficult to account, desired to have a state of his disbursements; an incivility which so much shocked the proud spirit of the patriotic president that he withdrew without deigning to make any reply. He had saved the country, yet they wished to huckster with him about pence. His services had been too great to be requited by any ordinary recompense, and hence they repaid him with ingratitude. It seems, also, that he had displeased the government of the day by the freedom and boldness with which he censured the barbarous system pursued, after the battle of Culloden, in a spirit of vindictive ferocity to which there has been no parallel in modern times, excepting, perhaps, in the wars of La Vendée. The ungrateful treatment which he experienced at the hands of the government he had saved is understood to have preyed on the spirits of President Forbes, and to have produced the fever of which he died in 1747, in the sixty-second year of his age. Throughout the whole course of his life he entertained a lively sense of religion, without the least taint of superstition; and his charity was indiscriminately extended to every sect and denomination of religionists. He was well versed in the Hebrew language; and wrote in a flowing style concerning theology and philosophy, particularly respecting the sources of incredulity. His writings, which had no reference to his profession, were, 1. Thoughts on Religion; 2. A Letter to a Bishop; and, 3. Reflections on Incredulity, 1750, in 2 vols. 12mo.

FORBES, *William*, bishop of Edinburgh, was born at Aberdeen in the year 1585, being the son of Thomas Forbes, a respectable citizen descended from Forbes of Corsinday, whose ancestor was the second son of the same Lord Forbes from whom Forbes of Corse derived his lineage. His mother was Janet the sister of Dr Cargill, an eminent physician. From the grammar school, where he had made uncommon progress, he was at the early age of twelve removed to Marischal College, and after the usual period of four years he took the degree of A. M. The principal, Gilbert Gray, was so much pleased with his scholarship and modesty, that he procured his appointment to the professorship of logic. It was his duty to teach the logic of Aristotle, whom he very strenuously defended against the attacks of Ramus. This office he resigned at the expiration of four years, and afterwards prosecuted his theological studies on the continent. Having landed at Dantzig, he travelled through a great part of Prussia and Poland. He studied in several of the universities, particularly those of Helmstädt and Heidelberg. Diligently resorting to the public libraries, he rendered himself familiar with the writings of the fathers and schoolmen; and in the Hebrew language he became a great proficient, or, according to the expression of his biographer, equalled the skill of any Jew. After spending four years in Germany, he went to Holland, and visited the university of Leyden, where his relation Dr Jack was then a professor of philosophy. He was anxious to extend his travels to France and Italy, but being deterred by the delicate state of his health, he sailed for England. From London he proceeded to Oxford, where his learning was held in so much estimation that he was offered the professorship of Hebrew in that university: but his countryman Dr Craig, physician to the king, advised him to consult his health by returning to his native air; and he accordingly arrived at Aberdeen, after an absence of five years, when, according to an obvious calculation, he must have attained the age of twenty-five. The corporation immediately conferred upon him the freedom of the city. When his health was in some measure restored, he was appointed minister of Alford, and was afterwards removed to Monymusk. He speedily acquired the reputation of a most eloquent preacher, and after a short interval he became one of the ministers of Aberdeen. During the king's visit to St Andrews in the year 1617, Forbes was created D. D. As the state of his health was still very infirm, he was willing to exchange his cure for an academical office. He was nominated principal of Marischal College, and discharged his duty with learning and zeal: he not only read lectures in divinity, but likewise taught the Hebrew language. After retaining the office for two years, he was induced to accept of a pastoral charge in Edinburgh, where however he soon discovered that his character and doctrines were held in much less estimation than in his native city. Aberdeen was the strong-hold of episcopacy, and its clergy were among the most learned and respectable of the episcopalians; but in Edinburgh the presbyterians were the predominant party, and Dr Forbes therefore found himself placed in a situation far from agreeable. When he already thought of resigning his living, his old friends at Aberdeen invited him to resume his spiritual labours among them, and there he continued to reside till near the close of his life. When King Charles visited Edinburgh in the year 1633, Forbes was one of those who preached before him; and the king was so much struck with his eloquence, that when he erected the new see, he spontaneously nominated him as the first bishop. His patent bears the date of January 26, 1634. He was consecrated in the month of February, and soon afterwards removed his wife and children to Edinburgh,[1] but he was not long permitted to enjoy his new dignity: he died on the 11th of April, before he had completed the third month of his episcopate, and when he had only attained the forty-ninth year of his age. His remains were interred in the cathedral church of St Giles.

Bishop Forbes was a man of very extensive reading, but he did not himself publish any work. He wrote copious animadversions on the works of Cardinal Bellarmin, and, after his death, these papers came into the possession of Dr Baron, who intended to prepare them for the press; but the national commotions speedily ensued, and this design was never executed, nor has their subsequent fate been ascertained. These animadversions, which his biographer describes as elaborate and nervous, filled the margin of the cardinal's works, printed at Paris in three volumes. Twenty-four years after the author's death, Thomas Sydserf, bishop of Galloway,[2] published "Considerationes modestæ et pacificæ Controversiarum de Justificatione, Purgatorio, Invocatione Sanctorum et Christo Mediatore, Eucharistia, per Gulielmum Forbesium, S. T. D. et Episcopum Edinburgensem primum. Opus posthumum, diu desideratum." Lond. 1658, 8vo. The preface, subscribed T. G., that is, Thomas Gallovidiensis, is followed by an account of the author's life. This volume, which was reprinted at Helmstädt in the year 1704, attracted a very considerable degree of attention, and is mentioned by many of the continental writers.[3] Any honest plan for promoting peace may seem to merit praise; but it is a very indifferent method of securing the peace of the church, by offering to meet the papists half-way. This is reforming backwards. The character of the learned author has thus been drawn by Bishop Burnet: "He was a grave and eminent divine: my father, that knew him long, and being of council for him in his law-matters, had occasion to know him well, has often told me, that he never saw him but he thought his heart was in heaven, and he was never alone with him but he felt within himself a commentary on these words of the apostles, 'Did not our hearts burn within us, while he yet talked with us, and opened to us the Scriptures?' He preached with a zeal and vehemence, that made him forget all the measures of time, two or three hours was no extraordinary thing for him; those sermons wasted his strength so fast, and his ascetical course of life was such, that he supplyed it so scantly that he dyed within a year after his promotion; so that he only appeared there long enough to be known, but not long enough to do what might have been otherwise expected from so great a prelate. That little remnant of his that is in print shews how learned he was. I do not deny but his earnest desire of a general peace and union among all Christians has made him too favourable to many of the corruptions in the church of Rome: but tho' a charity that is not well ballanced may carry one to very indiscreet things, yet the principle from whence they flowed in him was so truly good, that the errors to which it carried him ought to be either excused, or at least to be very gently censured."[4] (x.)

Forbes, *John*, one of the most learned divines whom Scotland has produced, was born on the second of May 1593. He was the descendant of an ancient and opulent family: his father was Patrick Forbes, bishop of Aberdeen, his mother was Lucretia the daughter of David Spence of Wormiston. His paternal ancestor was a younger son of Lord Forbes, and he was thus connected with some of the principal families in his native district.

Patrick Forbes was the eldest son of William Forbes of Corse and Oneill in the county of Aberdeen. William, the second son, bequeathed to his posterity the estates of Craigievar and Fintray. John, the third son, became minister of Alford, and, adhering with great zeal to the presbyterian discipline, was at length driven into exile on account of his having acted as moderator of the Aberdeen assembly. He settled in Holland, and successively officiated as a clergyman at Middelburg and Delft. His son Patrick Forbes quitted the presbyterians, and became bishop of Caithness in the year 1662. William's fourth son was Sir Arthur Forbes of Castle Forbes in the kingdom of Ireland, whose son was created earl of Granard: the father followed the profession of arms, and after quitting the Swedish service, had obeyed the call of fortune in Ireland, where he acquired an ample estate. The bishop of Aberdeen had other three brothers, of whom no particular notices have been preserved. He was himself educated at Stirling school, under Thomas Buchanan, an eminent classical master, and afterwards became a student in the university of Glasgow, where he was committed to the care of his distinguished kinsman Andrew Melville. When this learned man removed to St Andrews, in the year 1580, he was accompanied by Forbes, who applied himself to the study of the Hebrew language and of divinity with so much assiduity and success, and was so conspicuous for the propriety and gravity of his deportment, that a design was entertained of appointing him to a professorship in St Mary's College; but his father, who was already advanced in years, was anxious to see the heir of his estates otherwise settled, and, in compliance with this wish, the son relinquished his academic life. After his marriage, he fixed his residence near Montrose, and gained the respect of all his neighbours. Nor were his religious exercises confined to his own family: several of the churches in that vicinity were deprived of their pastors, and in one of these he regularly officiated for some time, till he was strongly urged by the bishop of the diocese, as well as by many other clergymen, to enter into holy orders. He was however unwilling to comply with this requisition, and the archbishop of St Andrews, who did not approve of lay-preaching, enjoined him to desist from the discharge of clerical functions. After a certain interval, which is not clearly defined, he consented to take orders, and was appointed parson of Keith, in the diocese of Moray. In the year 1618, he was elected bishop of Aberdeen, and he appears to have been one of the most exemplary prelates of that age. He was, says Bishop Burnet, "a gentleman of quality and estate, but much more eminent by his learning and piety, than his birth or fortune could make him. He had a most terrible calamity on him in his family, which needs not be named: I do not know whether that or a more early principle determined him to enter into orders: he undertook the labour of a private cure in the country, upon the most earnest invitations of his bishop, when he was forty-eight years old, and discharged his duty there so worthily, that within a few years he was promoted to be bishop of Aberdeen; in which see he sat about seventeen years. It was not easie for King James to perswade him to accept of that dignity, and many months passed before he could be induced to it, for he had intended to have lived and dyed in a more obscure corner. It soon appeared how well he deserved his promotion, and that his unwillingness to it was not feigned, but the real effect of his humility. He was in all things an apostolical man; he used to go round his diocess without noise, and but with one servant, that so he might be rightly informed of all matters. When he heard reports of the weakness of any of his clergy, his custome was to go and lodge unknown near their church on the Saturday night, and next day, when the minister was got into the pulpit, he would come to church, that so he might observe what his ordinary sermons were, and accordingly he admonished or encouraged them. He took such care of the two colledges in his diocess, that they became quickly distinguished from all the rest of Scotland: so that when the troubles in that church broke out, the doctors there were the only persons that could maintain the cause of the church; as appears by the papers that past between them and the covenanters. And though they begun first to manage that argument in print, there has nothing appeared since more perfect than what they writ. They were an honour to the church both by their lives and by their learning, and with that excellent temper they seasoned that whole diocess, both clergy and laity, that it continues to this day very much distinguished from all the rest of Scotland, both for learning, loyalty and peaceableness." Bishop Forbes is the author of several works, which deserve to be mentioned. The most considerable of them appear in a volume bearing the subsequent title: "An learned Commentarie vpon the Revelation of Saint Iohn, wherein both the covrse of the whole booke, as also the more abstruse and hard places thereof, are more cleerly and euidently explaned then heretofore they haue bene. Newly corrected, and the defectes and errors of the first edition supplied and amended. By Patrick Forbes of Cotharis. Wherevnto is added an profitable Treatise of the author, in defence of the lawfull Calling of the Ministers of Reformed Churches, against the Cauillations of Romanistes: and an Epistle to a Recusant, cleering and maintayning some pointes of the said Treatise, chalenged by a Roman Elymas Bar-Iesus-it." Middelburg, 1614, 4to. Of these different works a Latin translation was long afterwards published by his son Dr Forbes: "Commentarius in Apocalypsin, cum Appendice," &c. Amstelodami, 1646, 4to. Another work of the bishop is entitled "Eubulus, or a Dialogve, wherein a rugged Romish Ryme (inscrybed, *Catholicke Questions to the Protestant*) is confuted, and the Questions there-of answered. By P. A." Aberdene, 1627, 4to.

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[1] Spalding's History of the Troubles in Scotland, vol. i. p. 24. Edinb. 1828–9, 2 vols. 4to.—"Mr Andrew Forbes, one of the youngest sons to the bishop of Edinburgh, was professor of humanity in the town of St Jean d'Angel, near the town of La Rochelle." (Catalogues of Scotish Writers, p. 124. Edinb. 1833, 8vo.)

[2] Baillie's Letters and Journals, vol. ii. p. 426.

[3] Bibliotheque Choisie, tom. v. p. 396. Bayle, Dictionaire Historique et Critique, tom. ii. p. 1194.

[4] Burnet's Life of William Bedell, D.D. Bishop of Kilmore, pref. Lond. 1685, 8vo.—A portrait of Bishop Forbes may be found in Pinkerton's *Iconographia Scotica*, or Portraits of illustrious Persons of Scotland. Lond. 1797, 4to.

Of this worthy father, John Forbes was the second son. After having studied at Aberdeen, he was sent to the university of Heidelberg, where he was placed under the care of David Pareus, an eminent professor of divinity. He likewise prosecuted his studies at Sedan, and in some other universities which are not specified. Having devoted much time and labour to the acquisition of the Greek and Hebrew languages, and of all the variegated knowledge requisite for a theologian, he returned to his native country in 1619, being then in the twenty-sixth year of his age, and on the 27th of April he was admitted professor of divinity in King's College, Aberdeen. In this important vocation he laboured with great diligence, and speedily acquired the character of a most able and useful teacher. He was profoundly skilled in ecclesiastical antiquity; and, not contented with delivering what is called a system of divinity, he exhibited a very elaborate deduction of the progress of Christian doctrine in various ages of the church. Of the value of his instructions in this department, a very adequate opinion may be formed from the inspection of a work which he published in the maturity of his learning and judgment. Nor did he neglect to instruct his students in practical religion: one division of his lectures related to moral theology, another to the pastoral care and to residence.

While he was engaged in these useful and honourable labours, the kingdom was agitated by religious dissensions. Episcopacy, commonly described by the more odious name of prelacy, was no favourite with the great body of the people; and the five articles of Perth, passed in 1618, and relating to kneeling at the communion, the observance of festivals, confirmation, private baptism, and private communion, had excited a violence of opposition with which it was found very difficult to contend. Dr Forbes, who was as much distinguished by his piety as by his learning, endeavoured to promote peaceable measures; and with this view, he published his earliest work, bearing the title of "Irenicum Amatoribus Veritatis et Pacis in Ecclesia Scoticana." Aberdoniæ, 1629, 4to. Of this work he sent a copy to Archbishop Usher, who received it with much cordiality.[1] The bishop of Aberdeen did not live to witness the subversion of episcopacy: he died on the 28th of March 1635, in the seventy-first year of his age. As his eldest son had died ten years before, the professor of divinity succeeded to the family-estates. This prelate being regarded as the restorer of the university, and as a great pillar of the church, his death was sincerely lamented by the adherents of his own party. Soon after his decease, a volume, consisting of 429 pages, and including a portrait, was published under the following title: "Funerals of a Right Reverend Father in God, Patrick Forbes of Corse, Bishop of Aberdeen. Τοῦ ἐν ἁγίοις Reverendissimi in Christo Patris, Patricii Forbesii a Corse, Episcopi Abredoniensis, Tumulus, a multis omnium ordinum collachrymantibus variegato opere exornatus." Aberdene, 1635, 4to. Among other contributions, this volume includes English sermons by Dr Baron, Dr Scrogie, Dr Guild, Dr Sibbald, and Dr Ross, and a funeral oration in Latin by David Leitch, sub-principal of King's College. Besides Latin verses, Dr Forbes contributed a Latin sermon, and a "Dissertatio de Visione Beatifica." Among the contributors of Latin verses we find Robert Gordon of Straloch, Arthur Johnston, David Wedderburn, Patrick Panter, George Wishart, and Andrew Ramsay. The Latin and English or Scotish verses are numerous; and there is a Greek tetrastich by Robert Downie, the librarian of King's College.

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[1] See the Letters (p. 456.) subjoined to Dr Parr's Life of Usher. Lond. 1686, fol.

Dr Forbes, who was naturally disposed to think that nothing is better than peace,[1] next published "A peaceable Warning to the Subjects in Scotland; given in the yeare of God 1638." Aberdene, 4to. It was speedily answered in a tract ascribed to Calderwood, the most strenuous defender of the presbyterian cause. The introduction of the covenant involved the most conscientious of the episcopalians in inextricable difficulties. The professors and ministers of Aberdeen, who had recourse to argument and remonstrance, printed a paper containing "Generall Demands concerning the late Covenant." To this paper, which was subscribed by six doctors of divinity, Forbes, Scrogie, Lesley, Baron, Sibbald, and Ross, an answer was returned under the names of Alexander Henderson, David Dickson, and Andrew Cant, three individuals of no small influence among the covenanters. The doctors of Aberdeen subjoined replies to the answers; which produced further answers from Henderson and Dickson. The doctors published a rejoinder, and had the advantage of the last word;[2] but this was the chief advantage which they obtained, for all of them were deprived of their offices in the church and university, for their refusal to subscribe the covenant. William Lesley was principal of King's College, and appears to have been a man of erudition.[3] Robert Baron, a younger son of Baron of Kinnaird in the county of Fife,[4] was professor of divinity in Marischal College, and one of the city clergy. Being a great master of scholastic philosophy and theology, he published various works which procured him a high reputation, and he is described as "a person of incomparable worth and learning."[5] He was elected bishop of Orkney, but he died at Berwick in 1639, before he could be consecrated. Like Dr Lesley, he had been deprived of his office, and had been obliged to fly from Aberdeen. His brother Dr John Baron, professor of divinity at St Andrews, was finally induced to subscribe the covenant. Dr Forbes was treated with some degree of tenderness; and the covenanters being solicitous to gain such a convert, the proceedings against him in the ecclesiastical courts were protracted for several years. After some preliminary steps, he was in 1640 cited to appear at Aberdeen before a delegation of the general assembly. He was declared to be free from the taint of popery and Arminianism; but as he still adhered to episcopacy, and declined to subscribe the covenant, his case, through the influence of Baillie, was remitted to the presbytery of Edinburgh. He was allowed a month to yield satisfaction to this judicatory, and as he failed to do so, sentence of deprivation was pronounced against him. In 1643 he moved the synod of Aberdeen to make application to the general assembly, that he might be permitted to retain his professorship without subscription; but it was there determined that his deprivation was valid from the beginning.[6] He had purchased two houses adjoining to the college, and had assigned one of them to the professor of divinity, and the other to the *cantor*, a person on the foundation. In the deed of conveyance, he neglected to reserve to himself a life-rent in the professor's house; nor can it be mentioned without regret and indignation that he was obliged to vacate it for his successor in office.[7]

He was anxious to continue his residence in the university, for the benefit of prosecuting his researches in the public libraries; but he found that he must either subscribe the solemn league and covenant, or abandon his native country. Preferring the latter alternative, he embarked for Holland on the 5th of April 1644, and, after a voyage of five days, landed at Campvere. He travelled through the different provinces, and frequently preached in the Scotish and English churches. He had formerly married a lady of Middelburg, named Soete Roos-boom, who died on the 19th of January 1640. She was the mother of nine children; but only one of them, a son named George, was alive at the time of the father's exile. Dr Forbes chiefly resided at Amsterdam, and occupied himself in preparing for the press a work of great research and value. It appeared under the title of "Instructiones Historico-Theologicæ de Doctrina Christiana, et vario Rerum Statu, ortisque Erroribus et Controversiis, jam inde a temporibus Apostolicis ad tempora usque seculi decimi-septimi priora." Amst. 1645, fol. A second edition followed after a considerable interval. Genevæ, 1680, fol. And an abridgement of the work was published by Arnoldus Montanus, under the title of *Forbesius contractus*. Amst. 1663, 8vo. Forbes was enabled to prefix to his ample volume the favourable judgment of the theological faculties of Leyden, Utrecht, and Franeker, as well as that of Rivet, Maresius, and Vossius. This book established the reputation of the author as a theologian of a very high rank. Bishop Burnet speaks of it as "a work which, if he had finished it, and had been suffered to enjoy the privacies of his retirement and study, to give us the second volume, had been the greatest treasure of theological learning that perhaps the world has yet seen."[1] Dr Cave has likewise mentioned it as a work of great value,[2] and it has received similar commendation from writers of many different nations.

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[1] Οὐδέν ἐστιν ἄμεινον εἰρήνης. (S. Ignatii Epistolæ genuinæ, p. 17. edit. Smith.)

[2] The generall Demands of the reverend Doctors of Divinitie, and Ministers of the Gospell in Aberdene, concerning the late Covenant in Scotland; together with the Answeres, Replyes, and Duplyes that followed thereupon, in the year 1638. Reprinted in one book, by order of Parliament. Aberdene, 1663, 4to.

[3] See Garden, Vita J. Forbesii, p. 25.—In a letter dated in 1702, Bishop Sage conveys the following information: "The demands, replys, and duplys of the Doctors of Aberdeen, as I was informed when there, though subscribed by six, wer all formed and digested by Dr Lesley." (Catalogues of Scotish Writers, p. 131.) Middleton has however stated that Dr Baron "bare the greatest share in that famous debate."

[4] Sibbald's History of Fife and Kinross, append. Edinb. 1710, fol.

[5] Middleton's Appendix to Spotswood's History, p. 29.—Baillie, vol. i. p. 185, characterizes him as good Dr Baron. He subjoins, "I had great hopes, if he had lived a little, he should have quit them, and been glad to embrace the covenant of his mother church, as his learned brother now has done." Middleton speaks of John Baron as "a person of great worth and learning, and of great candour. He died in the time of our late combustions."

[6] Baillie's Letters and Journals, vol. i. p. 383.

[7] Spalding's Hist. of the Troubles in Scotland, vol. ii. p. 161. 190. Orem's Description of King's College, p. 84. 142.

After having resided upwards of two years in Holland, Forbes embarked at Campvere on the 8th, and arrived at Aberdeen on the 14th of July 1646. He immediately retired to his country-seat at Corse, and was permitted to spend the remainder of his days in learned and devout seclusion. He died on the 29th of April 1648, having completed the fifty-fifth year of his age. A short time before his death, he made application to the presbytery for permission to have his bones deposited in Bishop Dunbar's aisle in the cathedral church, beside those of his father and wife; but even this last favour was denied to a learned and excellent man, whose fault was a difference of opinion on the subject, not of Christian doctrine, but of ecclesiastical polity. He then directed his body to be interred in the churchyard of Leochel, where no monument was erected to his memory.[3] He left an only son, who is described by Dr Garden as the heir of his father's estates, but not of his virtues.

Dr Forbes was small in stature, and of a somewhat swarthy complexion. A person who had acquired such ample stores of erudition must have been an ardent and indefatigable student; and, with respect to his habits of study, we are informed that he always read and wrote in a standing posture. One of the few relaxations in which he indulged was the Scottish game of golf. With his extensive learning he united fervid and habitual piety. His conduct was upright and consistent in times of no small difficulty and distress.

An honourable monument was at length erected to his memory, in a collective edition of his Latin works. "Reverendi viri Johannis Forbesii a Corse, Presbyteri et SS. Theologiæ Doctoris, ejusdemque Professoris in Academia Aberdonensi, Opera omnia, inter quæ plurima posthuma, reliqua ab ipso auctore interpolata, emendata atque aucta." Amstelædami, 1703, 2 tom. fol. The second volume bears the date of 1702. The edition is introduced by two dedications, written by George Garden, D.D., an advertisement by Wetstein the printer, and a preface by Dr Gürtler, professor of divinity at Deventer. A copious life of the author, by Dr Garden, is next subjoined. The biographer, who appears to have been a very amiable man, was a regent in King's College, and afterwards minister of St Machar's, but was ejected from his living on the restoration of the presbyterian discipline. Under the title of "J. Forbesii Vita interior," he has added an abstract of Forbes's diary, which was written in English. One of the posthumous works is an ample treatise, entitled "Theologiæ Moralis libri decem; in quibus Præcepta Decalogi exponuntur, et variæ circa Dei Legem, et specialia ejusdem Præcepta, Controversiæ dissolvuntur, et Casus Conscientiæ explicantur." (x.)

FORCE, in *Philosophy*, denotes the cause of the change in the state of a body, when, from being at rest, it begins to move, or has a motion which is either not uniform or not direct. Whilst a body remains in the same state, either of rest or of uniform and rectilinear motion, the cause of its remaining in such a state is in the nature of the body, and it cannot be said that any extrinsic force has acted on it. This internal cause or principle is called *inertia*. See MECHANICS and PHYSICS.

FORCEPS, in *Surgery*, a pair of scissors for cutting off, or dividing, the fleshy membranous parts of the body, as occasion requires.

FORCER, in *Mechanics*, is properly a piston, without a valve. For by drawing up such a piston, the air is drawn up, and the water follows; and by pushing the piston down again, the water, being prevented from descending by the lower valve, is forced up to any height by means of a side branch.

FORCHEIM, a bailiwick of the circle of the Upper Maine, in the kingdom of Bavaria, extending over eighty-eight square miles. It contains one city, one market-town, and forty-one villages, with 11,500 inhabitants. It is an undulating country, productive in corn and pasture, and yielding some wine. The capital, of the same name, is a city situated on the river Regnitz, and containing 396 houses, with 3230 inhabitants, who have large breweries, paper-mills, glass-houses, tanneries, and iron forges at work.

FORDINGBRIDGE, a market-town of Hampshire, in the hundred of its own name, ninety-two miles from London. It is situated on the river Avon, on the borders of the New Forest. There are some manufactures of printed linen and calico. The market is held on Friday. The population amounted in 1801 to 2335, in 1811 to 2259, in 1821 to 2444, and in 1831 to 2611.

FORDUN, JOHN, the venerable father of Scottish history, apparently derives his surname from a village in the county of Kincardine, where he is supposed to have been born. He was not, as he has sometimes been represented, a monk, but a secular priest; and in some manuscripts of his history, he is described as a chaplain of the cathedral of Aberdeen; a title which Goodall seems to have considered as equivalent to canon. Bower describes him as a simple man, who had never graduated in the schools. He was engaged in the composition of his work towards the close of the fourteenth century. The first five books, and twenty-three chapters of the sixth book of the Scotichronicon, are the composition of Fordun: for the remainder of the work in its present form, we are indebted to Walter Bower, who was born at Haddington in the year 1385, and was unanimously elected abbot of St Colm in the year 1418. This monastery, situated in a small island in the Firth of Forth, belonged to the canons regular of St Augustin. The abbot is sometimes called Bowmaker, which is equivalent in signification to Bower. From 1395 to 1399 John Bowmaker appears as the deputy of the bailies or of the *customars* of Haddington, at the presentation of their accounts.[4] As the first of these dates is only ten years subsequent to the abbot's birth, and as he was a native of that town, this individual might possibly be his father or other relation. At the request of Sir David Stewart of Rossyth, he undertook to transcribe the papers of Fordun; but instead of executing a mere transcript, he inserted large interpolations, and continued the narrative to the death of James the First, having thus extended the work to sixteen books. Of this continuation the principal materials had however been collected by his predecessor. Bower professes to have been careful to distinguish what belonged to each; but as the negligence of subsequent copyists has omitted all his marks, we must chiefly be guided by the internal evidence in adjusting their respective claims. The Latinity of the Scotichronicon, though certainly far from being classical, is less barbarous than that of many other chronicles of the middle ages. Winton, the author of a chronicle in Scottish verse, is perhaps a more judicious writer than either Fordun or Bower, though his share of credulity and superstition is by no means inconsiderable. Beyond this period we have scarcely any records professedly historical, except the Chronicle of Melrose, and a few other fragments, neither considerable for their value nor extent.

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[1] Burnet's Life of Bedell, pref.

[2] Cave, Historia Literaria, p. xxx.

[3] Orem's Description of King's College, Aberdeen, p. 85.

[4] Accounts of the Great Chamberlains of Scotland, vol. ii. p. 290. 314. 360. 426.

It would be endless, as Nicolson has remarked, "to compute into how many several chronicles this of Fordon's has been multiply'd: for, being in every monastery of the kingdom under the anonymous title of *Scoto-chronicon*, it commonly borrowed a sirname from the place to which it belong'd."[1] The Black Book of Scone, and the Black Book of Paisley, were copies which obtained no small celebrity, and which seem to have been commonly regarded as two distinct chronicles compiled in those two monasteries. Thus, the Book of Pluscardine was a copy belonging to the priory of that name. Magnus Maccullooch and Patrick Russell, who are sometimes mentioned as continuators, were in all probability little more than transcribers of Fordun.

Some portions of the Scotichronicon were inserted in the collection of Dr Gale,[2] who obtained a defective copy, which he supposed to have belonged to Hector Boyce. In the year 1719, Richard Hay, a canon regular of St Augustin, issued "Proposals for Printing the Chronicle of John Fordun, with the Additions and Continuation of Walter Bowmaker, Abbot of Inch-Colm, containing the memorable things which happened in every year, since our first rise, to King James the First's death; conform to an authentick manuscript, belonging of old to one of our decay'd monasteries: with several notes, for clearing the dark parts of our history." The manuscript, "a large folio, written in old, but in glorious characters," belonged to the Cistertian monastery of St Mary at Cupar in Angus: it afterwards came into the possession of Hay, and is now deposited in the Advocates Library. He concludes his Proposals in the following manner: "Many persons of an eminent character have appeared desirous to have it printed, because what copies thereof were carried to England, France, Flanders, Italy, and elsewhere, during the heat of the Reformation, or our late disturbances, are properly lost for us. And what remain in the country, in private hands or in particular libraries, are of no use to the publick, whilst they are shut up, and as if it were hidden in obscure places, where scarce any number of men of an ordinar capacity are allowed access. Therefor I have been willing to publish this manuscript, with several notes, for the greater intelligence of our history, and a large preface, where I shall give an exact account of the fate and fortune of the most part of the others, transcribed by different hands, in former ages, with whom I have compared this original. The charges and expences of publishing this book will be certainly considerable. So those that are pleased to further and incourage this enterprize, are desired to pay ten shillings sterling at subscribing, and as much at the delivery of the printed copy, which will prove a good folio, on fine paper, and in good caracters, and will consist of 160 sheet and above. Their names and designations shall be insert in the front, and their respective houses or families shall be kindly remembered in the notes. As to the subscriptions, they are to be taken by the author, at his lodging in Howison's Land in the Potterraw; by Mr John Mackenzie of Delvin, at his lodging in the Parliament Close; by Mr Henry Massie, merchant, near the foot of Blackfriar-Wynd; by Mr William Adams, printer, over against the Trone-Church; by Mr Ruddiman in the Advocates Library; who shall deliver to the persons concerned the author's obligation to have the compleat copy remitted to them about the end of the following year, 1720, they paying ten shillings more at the time appointed." This plan was never carried into execution; but a valuable edition was soon afterwards published by Hearne, under the title of "Johannis de Fordun Scotichronicon genuinum, una cum ejusdem Supplemento ac Continuatione." Oxon. 1722, 5 tom. 8vo. The editor proceeds upon the plan of separating the interpolations of Bower from the text of Fordun. After an interval of nearly forty years, another edition was published by Walter Goodall, assistant-keeper of the Advocates Library: "Joannis de Fordun Scotichronicon, cum Supplementis et Continuatione Walteri Boweri, Insulæ Sancti Columbæ Abbatis." Edinb. 1759, 2 tom. fol. Goodall chiefly adheres to an excellent manuscript, written on vellum, and preserved in the library of the university of Edinburgh. (x.)

FORDYCE, David, professor of moral philosophy in Marischal College, Aberdeen, was born in that city in 1711. Having received the early part of his education at the grammar school, he, at the age of thirteen, entered the Greek class in Marischal College, Aberdeen; in 1728 he took the degree of master of arts, and in 1742 he was admitted professor of philosophy in the same college. Being originally designed for the church, he applied himself with great ardour to the study of divinity, in which he made great progress, though he never became a settled minister in the establishment of his native country. That he was well qualified to be such, however, appears from his *Theodorus*, a dialogue concerning the art of preaching, which he afterwards published. In 1750 he went abroad on his travels, in order to obtain fresh stores of knowledge; but after a successful tour through several parts of Europe, he was, on his return home, unfortunately cast away in a storm on the coast of Holland, in the forty-first year of his age. Besides the above work, he wrote *Dialogues on Education*, 8vo, and a Treatise on Moral Philosophy, published in the *Preceptor*. The third edition of his *Theodorus* was published in London, after his death, by his brother James, the subject of the following article.

Fordyce, *James*, a Scottish clergyman of considerable eminence, was born at Aberdeen in the year 1720. He received his classical education at the public grammar school, and afterwards entered Marischal College, where he went through the course of studies necessary to qualify him for being a minister of the gospel. His natural abilities were excellent, and having improved to the utmost the favourable opportunities he enjoyed at the university, he was considered as qualified for becoming a preacher of the gospel at an early period of life. His first appointment was that of second minister of Brechin, in the county of Angus, after which he accepted of a call to Alloa, near Stirling. The people of this parish were prepossessed in favour of another, and prejudiced against Mr Fordyce, which could not fail to prove an unpleasant circumstance; yet by his impressive delivery, and indefatigable attention to every part of his ministerial duty, he soon overcame their prejudice, and acquired their esteem and admiration.

During his residence at Alloa, he attracted the notice of the public by three sermons; the first on the eloquence of the pulpit, the second on the method of promoting edification by public institutions, and the third on the delusive and sanguinary spirit of popery, preached before the synod of Perth and Stirling. But still greater admiration was excited by his sermon on the folly, infamy, and misery of unlawful pleasure, preached before the general assembly of the church of Scotland in 1760. About this time the university of Glasgow conferred upon him the degree of doctor of divinity, probably on account of the fame he had acquired by this sermon.

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[1] Nicolson's Scottish Historical Library, p. 92.

[2] Historiæ Britannicæ Scriptores XV. vol. i. p. 565.

The friends of Dr Fordyce being mostly in the metropolis, he was invited to become the colleague of Dr Lawrence, minister of a respectable congregation in Monkwell Street, London, on whose death, which happened a few months afterwards, Dr Fordyce became once more celebrated for his pulpit eloquence, generally preaching to overflowing audiences. The best specimen of pulpit eloquence which perhaps proceeded from his pen was delivered at the ordination of Mr James Lindsay, who, after he declined officiating as a minister, became his successor. The remainder of his life he spent chiefly in retirement in Hampshire, in the vicinity of the residence of Lord Bute, with whom he lived in the greatest intimacy, and to whose valuable library he had unlimited access. He afterwards went to Bath, where he suffered much from an asthmatic affection, which he bore with the fortitude of a Christian, and expired without a groan on the first of October 1796, in the seventy-sixth year of his age.

The doctor's writings discover much genius and a correct taste, extensive knowledge of the world, and a happy method of engaging the attention. He was the author of 1. Sermons to Young Women, 1765, in 2 vols. 12mo; 2. A sermon on the Character and Conduct of the Female Sex; 3. Addresses to Young Men, 1777, in 2 vols. 12mo; 4. Addresses to the Deity, 1785, in 12mo; 5. A volume of Poems; 6. A discourse on Pain, 1791; and Additions to his brother's Temple of Virtue.

FORDYCE, *George*, a writer and lecturer on medicine, was born at Aberdeen in 1736, and studied at the university of that city, where he took the degree of master of arts at the early age of fourteen, perhaps not altogether owing to the superiority of his genius, or the extent of his acquirements, which could not be very extraordinary in a boy of his years. He became apprentice to an uncle who practised surgery at Uppingham in Rutlandshire, when he was only fifteen; and afterwards went to the university of Edinburgh, where his diligence and progress attracted the attention of Dr Cullen, at that time professor of chemistry, who very generously promoted his improvement. He graduated in 1758, when only twenty-two years of age; after which he resided during one winter at Leyden. The greater part of his patrimony having been spent on his education, he resolved to try his fortune in London, where he settled in the year 1759. He commenced with a course of lectures on chemistry; and although his encouragement at first was by no means flattering, yet he steadily and diligently persevered, notwithstanding unfavourable appearances, till his literary merit began gradually to be discovered and appreciated. A number of young men who came to study in London did not think that their medical course was complete without availing themselves of the benefit of his course of lectures. In the year 1768 he published his *Elements of the Practice of Physic*, which formed the text-book of his medical course, and were much read as a valuable epitome of medicine. His private practice was very respectable; and in the year 1770 his medical reputation was so great that he was chosen physician to the hospital of St Thomas, although he had to contend against a gentleman with very powerful interest; whilst his merit as a man of science procured him admission as a member of the Royal Society in 1776. In 1787 he was chosen a fellow of the College of Physicians; and his chemical knowledge was of much importance to that body in preparing a new edition of their Pharmacopœia. By the influence of his connections, but probably more so by his literary reputation, he was appointed to furnish the navy with sour krout, which we believe he executed with advantage both to himself and to the public. By this time, however, his constitution had discovered symptoms of premature decay; yet he continued to discharge his professional duties till he fell a victim to an irregular gout, and water in the chest, on the 25th of June 1802, in the sixty-sixth year of his age. If his lectures wanted the charms of an eloquent delivery, he made amends by the originality of his ideas and the extent of his scientific information. His works are, 1. Elements of Agriculture and Vegetation; 2. Elements of the Practice of Physick; 3. A Treatise on the Digestion of Food; 4. Four Dissertations on Fever, to which has been added a fifth, published from his manuscript since his death. His other works appeared in the *Philosophical Transactions*, to which he contributed eight papers, and on the *Medical and Chirurgical Transactions*, to which he contributed three.

FORECASTLE OF A SHIP, that part where the foremast stands. It is divided from the rest by a bulkhead.

FOREIGN, something extraneous, or that comes from abroad. The word is formed from the Latin *fores*, doors; or *foris*, out of doors; or *forum*, the market-place.

FOREIGNER, the natural-born subject of some foreign prince. Foreigners, though made denizens, or naturalized, are disqualified from bearing any office in government, being of the privy council, or members of parliament, &c. This is by the acts of the settlement of the crown.

FOREJUDGER, in *Law*, signifies a judgment by which one is deprived or put by a thing in question.

FORELAND, or FORENESS, in *Navigation*, a point of land jutting out into the sea.

North FORELAND, in the Isle of Thanet, Kent, of which it is the north-eastern point, is the promontory ascertained by act of parliament to be the most southern part of the port of London, which is thereby extended north in a right line to the point called the Nase on the coast of Essex, and forms what is properly called the Mouth of the Thames. A sea-mark was erected here by the Trinity-house corporation, at the public expense. All vessels which pass on the south side of this head-land are said to enter the Channel; and all the towns or harbours between London and this place, whether on the Kentish or Essex shore, are called members of the port of London.

South FORELAND, in Kent, a head-land forming the eastern point of the Kentish shore; and called *South*, in respect to its bearing from the *North* Foreland, which is about six miles to the north. Its situation is a great security to the Downs, the road between both, which would be very dangerous for ships, did not this point break off the sea, which would otherwise come rolling up from the west to the Flats; so that these two capes breaking all the force of the sea on the south-east and south-west, make the Downs be accounted a good road, excepting when the wind blows excessively hard from south-east, east-by-north, or east-north-east, when ships in the Downs are driven from their anchors, and often run ashore, or are forced on the sands, or into Sandwich Bay, or Ramsgate Pier.

FORE-LOCKS, in nautical language, little flat wedges made of iron, used at the end of bolts, to keep them from flying out of their holes.

FOREMAST OF A SHIP, a large round piece of timber, placed in her fore part or forecastle, and carrying the fore-sail and fore-top-sail yards. Its length is usually eight ninths of the main-mast, and the fore-top-gallant mast is half the length of the fore-top.

FOREST, in *Geography*, a large extent of ground covered with trees. The word is formed from the Latin *foresta*, which first occurs in the capitulars of Charlemagne, and which is itself derived from the German *frost*, signifying the same thing. Spelman derives it from the Latin *foris restat*, by reason forests are out of towns. Others derive *foresta* from *feris*, that is, *Foresta, quod sit tuta statio ferarum*, as being a safe station or abode for wild beasts.

The Caledonian and Hercynian forests are famous in history. The former was a celebrated retreat of the ancient

Picts and Scots; and the latter, in Cæsar's time, extended from the borders of Alsatia and Switzerland to Transylvania, being computed at sixty days' journey in length, and nine in breadth. The ancients venerated forests, and imagined that a great part of their gods resided therein. Temples were frequently built in the thickest forests, the gloom and silence of which naturally inspire sentiments of devotion. For a similar reason the Druids made forests the place of their residence, performing sacrifices, instructing youth, and giving laws in their umbrageous recesses.

Forest, in *Law*, is defined, by Manwood, a certain territory of woody grounds and fruitful pastures, privileged for wild beasts and fowls of forest, chase, and warren, to rest and abide under the protection of the king, for his princely delight; bounded with unremoveable marks and meres, either known by matter of record or prescription; replenished with wild beasts of venery or chase, with great coverts of vert for the said beasts; and for preservation and continuance whereof, the vert and venison, there are certain particular laws, privileges, and officers. Forests are of such antiquity in England that, excepting the New Forest in Hampshire, erected by William the Conqueror, and Hampton Court, erected by Henry VIII. it is said that there is no record or history which makes any certain mention of their erection, though they are mentioned by several writers and in several of our laws and statutes. Ancient historians tell us that New Forest was raised by the destruction of twenty-two parish churches, and many villages, chapels, and manors, for the space of thirty miles together, which was attended with divers judgments on the posterity of William I. who erected it: for William Rufus was there shot with an arrow, and before him Richard the brother of Henry I.; and Henry, nephew to Robert, the eldest son of the conqueror, was, like Absalom, suspended by the hair of the head in the boughs of the forest.

A forest in the hands of a subject is properly the same thing as a *chase*, being subject to the common law, and not to the forest laws. But a chase differs from a forest in this, that it is not enclosed, and likewise, that a man may have a chase in another man's ground as well as his own, that is, the liberty of keeping beasts of chase or royal game therein, protected even from the owner of the land, with a power of hunting them thereon.

The manner of erecting a forest is this: Certain commissioners are appointed under the great seal, who view the ground intended for a forest, and fence it round; and this commission being returned into chancery, the king causes it to be proclaimed throughout the country where the land lies, that it is a forest, prohibiting all persons from hunting therein without his leave. Though the king may erect a forest on his own ground and waste, he may not do it on the ground of other persons without their consent; and agreements with them for that purpose ought to be confirmed by parliament.

A forest, strictly speaking, cannot be in the hands of any but the king; for no person except the king has power to grant a commission to be justice in eyre of the forest. Yet, if he grants a forest to a subject, and that on request made in the chancery, such subject and his heirs shall have justices of the forest; in which case the subject has a forest in law.

Forest-Laws, are peculiar laws, different from the common law of England. Before the making of the *Charta de Foresta*, offences committed therein were punished at the pleasure of the king in the severest manner. By this charter many forests were disforested and stripped of their oppressive privileges, and regulations were made for the government of those which remained; in particular, killing the king's deer was declared to be no longer a capital offence, but only punishable by fine, imprisonment, or abjuration of the realm. Yet even in this charter there were some grievous articles, which the clemency of later princes has since thought fit to alter *per assisas forestæ*. And to this day, in trespasses relating to the forest, *voluntas reputabitur pro facto*; so that if a man be taken hunting a deer, he may be arrested as if he had taken a deer.

FORESTALLING, in *Law*, buying or bargaining for any corn, cattle, victuals, or merchandise, when on the way to fairs or markets to be sold, before they get thither, with an intent to sell the same again at a higher price.

FORESTER, a sworn officer of the forest, appointed by the king's letters patent, to walk the forest at all hours, and watch over the vert and venison; also to make attachments and true presentments of all trespasses committed within the forest.

FORFAR, a county in Scotland, bounded by the shires of Aberdeen and Kincardine on the north, the German Ocean on the east, the Frith of Tay, which separates it from Fife, on the south, and the county of Perth on the west. It is situated between 56° 27′ and 57° north latitude, and between 2° 28′ and 3° 22′ west longitude from Greenwich, and extends from north to south from twenty-six to thirty-four miles, and twenty-three to thirty from west to east. It contains, by the lowest computation, 832 square miles, or 532,480 English acres, without including portions of the parishes of Lundie, Cupar, and Alyth, the greater part of which belongs to the county of Perth.

More than a third of its area is occupied by the Grampians, here called the Binchinnin Hills, on which it meets the Braes of Mar in Aberdeenshire. The surface of this northern division of the county, or the Braes of Angus, with the exception of the mountains at the head of Glen Clova, is not in general so bold and abrupt as many other alpine districts of Scotland; the hills are for the most part rounded, and rather tame, and covered with a thin coat of moorish soil, carrying stunted heath. Catlaw, the highest, is 2264 feet above the level of the sea. There are several considerable valleys in this district, the principal of which are Glen Isla, Glen Prosen, Clova, Lethnot, and Glen Esk, which are watered by streams that rise in the west and north, and commonly flow south-east, receiving innumerable torrents from the mountains in their progress. South from the Grampians, and parallel to them, is another but lower range, called the Siedlaw Hills, supposed to be a continuation of the Ochils; some of these hills are 1400 feet in height. Between these two grand divisions lies Strathmore, the Great Valley, as the name denotes in Gaelic, or, as it is commonly called, the How of Angus, extending about thirty-three miles in length, and from six to eight in breadth; a district beautifully diversified by gentle eminences, fertile fields, plantations, villages, and gentlemen's seats, very little of it being 200 feet above sea level. It was at one time proposed to carry a canal through this valley, which might be extended to Dumbarton, and thus connect the three great rivers of Scotland, the Clyde, the Forth, and the Tay; another from Arbroath to Forfar was also in contemplation; but neither of them has been carried into effect. The fourth, and remaining division, extends from the Siedlaw Hills to the German Ocean on the east, and the Frith of Tay on the south, and is, with a few exceptions, a rich and well-cultivated tract, varying in breadth from three to eight miles, and comprehending about a fourth part of the whole county.

The woods and plantations have been computed to extend to 35,000 acres, of which about 5000 consist of coppice and natural wood. Several of the Grampian glens are sprinkled with birches, oak, and hazels. The botany and zoology of the county were explored with great industry some years ago by Mr George Don of Forfar, who presented a very ample enumeration in both departments, in a paper subjoined to Mr Headrick's *Survey for the Board of Agriculture*.

The general colour of the soils is red, but often inclining to dark brown or black. In the Grampians the soil is often moorish, over whitish retentive clay, but loose and friable in the glens. Over the puddingstone or gravelstone rock in the lower grounds, it is sometimes thin, mossy, and encumbered with stones; and over the sandstone a tenacious clay occurs. The soil above whinstone is fertile, though sometimes shallow. In Strathmore it is often gravelly, in other parts a dead sand. There is no great extent of moss; but what exists is of much value for fuel.

The mineralogy of a considerable portion of Forfarshire was examined by Colonel Imrie, who has given a minute description of it in a paper published in the sixth volume of the *Transactions of the Royal Society of Edinburgh.* In the Grampian district, towards the summit of the county, on the confines of Aberdeenshire, the prevailing rock is granite, some of it very beautiful, with topazes or rock-crystals in its cavities or fissures, known by the name of *cairngorums*, from a mountain of that name in Aberdeenshire; also micaceous schistus, and porphyry dykes of the latter in some places intersecting the former. Laminated talc or mica, called by the shepherds *sheep's siller*, from its silvery lustre, which is sometimes thickly studded with small garnets, is found in irregular veins, and siliceous spar in jutting or detached hills. Lead was wrought at Gilfianan, above the old castle of Innermark, in the upper part of the parish of Lochlee, and also at Ardoch, near Mill-den, on the Esk. At the former place, according to Edward, in his *Description of Angus*, published in 1678, it yielded one sixty-fourth part of silver; but both mines have long since been abandoned. Limestone in small quantities frequently occurs, and is wrought in several parts; there are also broad veins of slate, but which, it is said, does not come off in plates of sufficient size for use. In descending the Grampians to Strathmore, gravelstone prevails, and afterwards, on the lower grounds, sandstone. Clay marl is found both in Strathmore and the Siedlaw Hills, but is little used. Shell marl is in greater request, and abounds in different parts, particularly in the lochs of Kinordie, near the bottom of the Grampians, Lundie in the Siedlaw Hills, Logie in the parish of Kirriemuir, and Restennet near Forfar. These lochs have been drained and rendered of easy access. It is also found in the lochs of Forfar, Rescobie, and Balgavies, where it is raised by scoops, and conveyed to the shore in boats. The Siedlaw Hills are chiefly composed of sandstone of various colours, some of it susceptible of a high polish. Sandstone flags, which are much used instead of slate for covering roofs, are raised in great quantities on the hill of Balmashanner, and in the moor to the south of Forfar; but the most extensive range of these flags is in the parish of Carmylie, and along the southern declivity of the Siedlaw Hills. The principal lime-works are in the maritime division, at Hedderwick near Montrose, and at Boddin in the parish of Craig, upon the sea-shore. The only mineral springs are chalybeate, one of which is near Montrose, another to the west of Arbroath, two in the side of a rivulet about a mile farther west, and one in the north-west corner of Dumbarrow in the parish of Dunichen.

The heaviest rains are from the east and south-east, and the heaviest snows from the north and north-east. At Crescent, half a mile westward of Dundee, the quantity of rain that fell during six years, from 1790 to 1795 inclusive, varied from 22·27 to 34·12 inches; but at Belmont, in the centre of Strathmore, during the same years, it was from 31·45 to 39·55 inches. The mean height of the barometer at Belmont, during the first three of these years, was 29·60, and that of the thermometer 42°. At Crescent, the mean degree of cold during winter, for the whole period, was from $32\frac{1}{3}^\circ$ to $39\frac{2}{3}^\circ$, and of heat during summer, from $60\frac{1}{5}^\circ$ to 66°. The south-east wind blows at Crescent twenty-one, and the south-west one hundred and nine days annually; whereas at Belmont the former prevails eighty-five and the latter one hundred and thirty-eight days.

The principal lochs or lakes have been already mentioned as containing shell-marl. To these may be added Lochlee among the Grampians, from which the North Esk issues, and Lentrathan near their base. None of the streams are so considerable as to have the name of rivers, but are called waters. The *North Esk*, after leaving Lochlee, flows towards the east, and then the south-east, where it forms the boundary between this county and Kincardineshire, and falls into the sea about three miles north-east of Montrose, having received the Mark, the Tarf, the Westwater, and the Cruick in its course. The *South Esk* rises in the north-western part of the county, among the Grampian summits of Clova, and passing by Brechin, discharges itself into the basin of Montrose, five miles from the mouth of the North Esk, after being joined by the waters of Prosen, Carritty, and other mountain streams. Its general course is from north-west to south-east. *Isla*, the last stream of any note, has also its source in the Grampians, flowing from the summit of the glen which bears its name, in a direction from north to south, until, at Ruthven, it bends to the westward, and joins the Tay in Perthshire. Below the bridge of Craig it has cut a chasm, in some places more than a hundred feet in depth, through a barrier of porphyry and gravelstone rocks, where it forms cascades of singular beauty. The Dean, the Lunan, the Dighty, and a few others, are inconsiderable streams.

Much of the landed property of Forfarshire has changed its owners within the last century; and of the forty barons mentioned by Edward, in the work already referred to, the descendants of not more than a third of them now possess estates in it. It is in general divided into estates of a moderate size. In 1811 a large proportion were from L.100 to L.1000 a year, some from L.2000 to L.6000; but only one or perhaps two worth L.12,000 a year. About a third part of the county is now held under entail. The valued rent is L.171,239. 16s. 8d. Scots, which is divided amongst two hundred and sixty-six estates, three fourths of which are below L.500 Scots. The real rent of the lands in 1811 was L.260,196. 15s., which is less than 10s. an acre; and of the houses, L.64,108 sterling. There are more than sixty gentlemen's seats, some of them venerable for their extent and antiquity, such as the Castles of Glammis, Brechin, and Airly, the house of Panmure, and others, distinguished for elegance and the beauty of their situation. Amongst the latter, Kinnaird Castle, the seat of Sir James Carnegie, is the most magnificent.

Farms are of every size, but in general not large, the average size of such as are arable being from 100 to 250 acres. There is a greater number below than above 100 acres. According to the *Agricultural Survey*, the whole number of farms in 1808 was 3222, of which about the half were under L.20 of yearly rent, and only eighty-six above L.300. In the western division of the Grampian district, the arable land is still held in runrig or intermixed, and the mountains in common, either without leases, or on leases not exceeding nine years. Throughout the rest of the county the leases are commonly for nineteen or twenty-one years. The farm-houses lately erected in the lower parts of the county are in general convenient and comfortable, but in the Grampians they are still miserable huts, with walls of stone and turf alternately, five feet high, and covered with thatch fastened with ropes in the form of a hay rick. In some parts where stones are scarce, cottages and even small farm-houses are built with clay, wrought up and mixed with straw, but in general the cottages are built with stone and clay, with clay floors and thatched roofs, one of which may be constructed for about L.15. Their number has been much diminished of late.

The agriculture of Forfarshire is for the most part respectable, though modern improvements are not so general as in the Lothians and border counties of Scotland. Wheat, which, according to Pennant, was a rare crop in 1775, is now cultivated to a great extent upon almost every variety of soil, to the height of 800 feet above the level of the sea; also barley, and all the other farm crops common in Scotland. In reaping the corn crops there is a practice peculiar to this and one or two of the contiguous counties, called *threaving;* the reaper is paid for his work not by the acre or by day-wages, but according to the number of sheaves he cuts down, or by the *threave,* which contains twenty-four or twenty-eight sheaves, the girth of which is specified. The advantages of this practice are, that women and children, who cannot perform full labour, find employment, working in families, on different parts of a field; whilst the farmer gets his crops cut low and clean, from its being their interest to fill the sheaf with the thickest part of the straw, which is always that nearest the ground. The unmarried men-servants, instead of boarding in the farmer's own house, often live apart in a place called the *bothy,* where they cook their own victuals.

No great progress has been made here in the improvement of live stock. The *garron,* a small breed of horses, keeps its ground in the Grampians, where the number employed is much too considerable for the work they have to perform. The Lanarkshire or west-country breed is common in the lower districts. There is supposed to be more than 9000 horses of all kinds and ages in the county, which were valued in 1811 at L.220,270. The cattle in the cultivated parts, when fat, weigh from forty to sixty stones, and in some instances a great deal more; and many more are fattened than reared, the practice on the grazing lands being to purchase them from the counties of Kincardine, Aberdeen, and Moray, and after making them fat, or nearly so, to sell them for the markets in the south. They are accordingly of a variety of breeds. Many of the permanent or stationary stock are without horns, and seem to be allied to the Galloways. Oxen were formerly employed in labour; but they are now rarely used except in turning up soils overrun with broom and other shrubs. The permanent stock of cattle is said to be about 37,400, worth L.261,800. There are few flocks of sheep, except in the Grampians and the highest of the Siedlaw Hills, though almost every residing proprietor, and many of the farmers, keep a small number. The original breed is the small white or yellow-faced; but the Linton, or black-faced, is the most numerous. The number is computed at 60,000, and the value at L.42,000. A herd of fallow-deer is kept in the park at Panmure.

Forfarshire contains five royal burghs, with a number of villages and hamlets; and a pretty large proportion of its inhabitants are employed in manufactures and commerce. The royal burghs are, 1. Forfar, the county town; 2. Dundee; 3. Aberbrothick, or Arbroath; 4. Montrose; and 5. Brechin. To these may be added Kirriemuir, a considerable village; Cupar Angus, of which, however, only a small part is in this county, most of it being in Perthshire; Glammis, Douglastown, and Letham. In 1808, 11,269,867½ yards of linen were stamped for sale in the county, the value of which was nearly half a million sterling. About half as much more, which was not stamped, might be made for domestic use and private sale.

There are two customhouses in Forfarshire; one at Dundee, and another at Montrose. For an account of the Dundee shipping trade, see the article DUNDEE. That at Montrose, including Johnshaven and Gourdon, amounts to 108 vessels, about 11,000 tons.

The fisheries on the coast of this county have not been prosecuted with great success. The boats employed are generally small, requiring only four hands. For some years considerable quantities of herrings have been caught in the months of June, July, and August. But the river fisheries have become of great value since the plan was adopted, at the suggestion of the late Mr Dempster of Dunichen, of conveying fresh salmon to London packed in ice. Mr Headrick estimates the produce of six of these fisheries in 1810 at L.7450. The greatest salmon fisheries are in the Frith of Tay, and were carried on chiefly by stake-nets, a practice which was objected to by the proprietors higher up the river, and which has been since declared illegal *intra fauces terræ,* or within the estuary.

Many religious and military ruins are to be found in Forfarshire. Near the cathedral of Brechin is a curious round tower, of which, though such be common in Ireland, only two, it is said, have been observed in Britain; this, and another similar to it at Abernethy, in Perthshire. (See the article BRECHIN.) At Arbroath are the remains of an abbey, founded by William the Lion in 1178, and very richly endowed, where was held the parliament of Robert Bruce which addressed the celebrated remonstrance to the Pope, asserting the independence of the kingdom. A hill fort called *Cater-thun,* in the parish of Menmuir, north-west of Brechin, is worthy of notice. Pennant thinks it was one of the posts occupied by the Caledonians before their engagement with Agricola, at the foot of the Grampians.

The county of Forfar sends one member to Parliament; the burgh of Dundee one; and Inverbervie, Montrose, Arbroath, Brechin, and Forfar one, Montrose being the returning burgh. It contains fifty-three entire parishes, besides portions of three others, which belong to presbyteries that meet at Forfar, Dundee, Brechin, Meigle, and Arbroath, and which, with the presbytery of Fordun, compose the synod of Angus and Mearns. There is no assessment for the poor in the county.

See Edward's *Description of Angus,* reprinted in 1791, and Colonel Imrie's *Section of the Grampians,* already referred to; *Beauties of Scotland,* vol. iv.; Headrick's *General View of the Agriculture of Angus or Forfarshire; Memoirs of the Wernerian Society,* vol. ii.; *The General Report of Scotland;* and Playfair's *Description of Scotland,* vol. i.

The following are the returns of the population for the years ending 1811, 1821, and 1831.

YEAR.	HOUSES.			OCCUPATIONS.			PERSONS.		
	Inhabited.	By how many Families occupied.	Uninhabited.	Families chiefly employed in Agriculture.	Families chiefly employed in Trade, Manufactures, or Handicraft.	All other Families not comprised in the two preceding classes.	Males.	Females.	Total of Persons.
1811	16,135	24,750	505	4980	13,616	6154	48,151	59,113	107,264
1821	16,812	26,718	576	5114	15,348	6256	52,071	61,359	113,430
1831	...	...	...	...	...	...	65,093	74,513	139,606

Forfar, a royal burgh of Scotland, and capital of the county of Forfar, is situated in the lowest part of the county, which declines to it on all sides, and has rather a pleasant appearance. The streets are by no means regular, but many of the houses are well built and neat; an improvement, however, which has taken place within the last few years. At the beginning of the present century its streets were chiefly composed of old thatched houses, and its church was in a state of decay. But the town is now ornamented with a handsome suit of county buildings, situated in a good street. A new church with a steeple has likewise been erected, and an Episcopal chapel was opened in 1823. Besides these places of worship, some sects of dissenters have meeting-houses here. Forfar being the seat of the county courts of the sheriff, possesses a number of public offices and legal practitioners. There is a parish school, and an academy, where the languages, mathematics, and geography are taught. It has also an excellent news-room and library. The chief trade of Forfar is the weaving of osnaburgs and coarse linens. From time immemorial however it has been celebrated for the manufacture of *brogues* or strong shoes, such as are fitted for the rugged soil of the Highlands, where they are principally used by the inhabitants.

Forfar is a royal burgh of unknown antiquity, the privileges of which were confirmed in 1669, in virtue of which it is governed by a provost, two bailies, and nineteen counsellors, who are elected annually. The revenue of the burgh may be averaged at L.1000. On the west side of the town there is a beautiful sheet of water, which, although considerably reduced by draining, is still about a mile in length by half a mile in breadth. In former times Forfar was protected by a castle, which stood on a mound to the north of the town. Its origin is uncertain, but it is believed to have been the place where the first parliament of Malcolm Ceanmore assembled, after the destruction of Macbeth. The site of this ancient fortress is now marked by the town cross, which was removed by the magistrates some years ago, for the purpose of pointing out where the royal residence had been. Forfar has shared in the general advancement of population, trade, and agricultural improvement, and it is now one of the most comfortable little towns in the county. It lies fourteen miles north from Dundee, and fifty-six from Edinburgh. In 1821 the population, including the parish, amounted to 5897, and in 1831 to 7944.

FORFEITURE originally signifies a transgression or offence against some penal law. The word is formed from the base Latin *forisfactura*, whence *forfaitura* and *forfaictura*, and the French *forfait*. *Forisfactura* comes from *forisfacere*, which, according to Isidore, signifies to hurt or offend, *facere contra rationem*; and is not improbably derived from *foris*, out, and *facere*, to do, an action out of rule, or contrary to the rules. Borel thinks *forfait* is derived from the using of force or violence; and Lobineau, in his glossary, supposes *forisfacta* properly to signify a mulct or amend, not a *forfeit*, which latter he derives from the Bas-Breton, *forfed*, a penalty. But with us it is now more frequently used for the effect of such transgression, as the losing some right, privilege, estate, honour, office, or effects, in consequence thereof, than for the transgression itself. Forfeiture differs from confiscation in this, that the former is more general; whilst confiscation is particularly applied to such things as become forfeited to the king's exchequer; and goods confiscated are said to be such as nobody claims. See Treason.

FORFEX, in Roman antiquity, was a method of drawing up an army in the form of a pair of sheers, and intended to receive the *cuneus* or wedge, if the enemy should make use of that formation.

FORFICULA, the Earwig, a genus of insects belonging to the order of coleoptera. See Entomology.

FORGE properly signifies a small furnace, in which smiths and other artificers of iron, steel, or other metals, heat these metals red hot, in order to soften them and render them more malleable and manageable on the anvil.

An ordinary forge is nothing but a pair of bellows, the nozzle of which is directed upon a smooth area, on which coals are placed. The nozzle of a pair of bellows may also be directed to the bottom of any furnace, to excite the combustion of the coals placed there, by which a kind of forge is formed. In laboratories there is generally a small furnace consisting of one cylindrical piece, open at top, which has at its lower side a hole for receiving the nozzle of a double bellows. This kind of forge furnace is very convenient for fusions, as the operation is quickly performed, with a small expenditure of fuel. In its lower part, two inches above the hole for receiving the nozzle of the bellows, may be placed an iron plate of the same diameter, supported upon two horizontal bars, and pierced near its circumference with four holes diametrically opposite to each other. By this disposition, the wind of the bellows, pushed forcibly under this plate, enters at these four holes; and thus the heat of the fire is equably distributed, and the crucible in the furnace is surrounded by it. This contrivance is used in the forge-furnaces for smelting copper; with this difference only, that these furnaces are square, which, however, is a matter of little consequence.

As the wind of bellows strongly and rapidly excites the action of the fire, a forge is very convenient when a great heat is to be applied quickly; but it is not suitable when the heat is to be gradually increased.

Forge is also used for a large furnace, in which iron ore, taken out of the mine, is melted down; or it is more properly applied to another kind of furnace, in which the iron-ore, melted down and separated in a former furnace, and then cast into sows and pigs, is heated and fused over again, and beaten afterwards with large hammers, and thus rendered softer, purer, more ductile, and better fitted for use. See Furnace.

FORGERY (from the French *forger*, signifying *accudere, fabricare*, to beat on an anvil, forge, or form), may be defined at common law to be the fraudulent making or alteration of a writing, to the prejudice of another man's right; or it is the crime of imitating the subscription of another, adhibiting it to a deed, and putting that deed to use by acting under it, receiving property in virtue of it, founding on it as a title to sue or to defend, or transferring it to another. In considering forgery, it is necessary to attend, first, to the mode of proof by which the crime is established; and, secondly, to the punishment which is inflicted on the perpetrator thereof.

The proof of forgery is either direct or indirect. The direct proof consists in the examination of the writer of the deed, and of the witnesses who sign the deed and attest the subscription. As the subscription of witnesses is an attestation to which the law gives effect to the extent of receiving it on their death as evidence of the regularity of the deed, and as weight is given to the subscription of a witness, even where he does not recollect having adhibited it; so, to cut down a deed regularly attested, the instrumentary witnesses, as they are called in Scotland, must be brought to swear to circumstances of sufficient force to invalidate the evidence given by their subscriptions; a species of proof which the law does not and indeed cannot reject. The indirect mode of proof consists in an investigation of all the circumstances from which it may be inferred that the person by whom a deed is said to have been executed actually did not subscribe; as, for instance, an error in the date, an *alibi*, the stamp, the contexture of or date impressed upon the paper, or a *comparatio literarum*. The comparison of the handwriting is made with genuine subscriptions of the same date as that alleged to have been forged; and where the real subscriptions differ materially from the one founded on, the forgery of the latter may be pronounced on with a considerable degree of certainty. The indirect mode of proof, however, is not resorted to where the direct mode is practicable.

Until recently the punishment of forgery was not expressly laid down by statute; but by the common law and practice of the country, conviction was usually followed by a capital punishment in all cases of gross forgery; whilst those of less moment, as forgeries of executions, or where the evidence was not in every respect conclusive, were commonly visited with what in Scotland is denominated an arbitrary punishment, that is, with imprisonment or transportation. Latterly, however, the severity of the law in this particular has been considerably mitigated, and the punishment of death restricted to those cases of forgery which are not only the most aggravated in their own nature, but at the same time calculated to prove most extensively injurious to the interests and well-being of society. By the 2d and 3d William IV. c. 123, entitled an "act for abolishing the punishment of death in certain cases of forgery," it is enacted that where any person shall thereafter be convicted of any offence whatsoever for which the 1st William IV. c. 66 (entitled an "act for reducing into one all such forgeries as shall hereafter be punished with death, and for otherwise amending the laws relative to forgery") enjoins or authorizes the infliction of the punishment of death, or for any offence which shall consist wholly or in part of forging or altering any writing, instrument, matter, or thing whatsoever, or of offering, uttering, or disposing of any writing, instrument, matter, or thing whatsoever, knowing the same to be forged or altered, or of falsely personating another, such offender shall not suffer death, or have sentence of death awarded against him, but shall be transported beyond seas for the term of such offender's life. But it is at the same time specially provided that nothing in this act shall be construed to extend to the forging or altering, offering, uttering or disposing of, knowing the same to be forged or altered, any will, codicil, or testamentary writing, with intent to defraud any body corporate or person whatsoever, or of forging or altering, or of uttering knowing the same to be forged, any power of attorney or other authority to transfer any share or interest in any stock, annuity, or other fund, transferable at the Bank of England or South-Sea House, or Bank of Ireland, or to receive any dividend payable in respect of such share or interest, with intent to defraud any body corporate or person whatsoever, or of procuring, aiding, or assisting in the commission of such offences, for all which offences the punishment of death is to continue the same as if this act had not been passed. And further, by 2d and 3d William IV. c. 44, it is enacted that persons punishable with transportation for life under the foregoing act shall be liable, previously to their being transported, in case the court before which they are convicted shall think fit, to be imprisoned, with or without hard labour, in the common gaol or house of correction, or to be confined in the penitentiary for any term not exceeding four years nor less than one. Such is now the state of the law on this subject. As it formerly stood its excessive severity had rendered it to a certain extent inoperative; for as the natural feelings of mankind revolt at the indiscriminate sacrifice of human life for offences of a secondary description, judges and juries had tacitly combined to evade giving it effect in the less aggravated class of cases, and thus to reconcile with public opinion the practical administration of justice in this particular. But as all such evasions, however humane in their spirit, are pregnant with manifold evils, it is to be hoped that the mitigation which has taken place will augment the efficacy of the law by increasing the certainty of the punishment it awards, and that hence will result a diminution in the number of offences of this kind, which the excessive but irregular severity of the law, as it formerly stood, had failed to produce. (A.)

FORGING, in smithery, the beating or hammering iron upon an anvil, after having first made it red hot in the forge, in order to extend it into various forms, and fashion it into various works.

There are two ways of forging and hammering iron. The first is by the force of the hand, in which there are usually several persons employed, one turning the iron and likewise hammering, and the rest only hammering. The other way is by the force of a water-mill, which raises and works several huge hammers beyond the force of man, under which the workmen place large lumps or pieces of iron, which are sustained at one end by the anvils, and at the other by iron chains fastened to the ceiling of the forge. This last way of forging is only used in the largest works, as anchors for ships, which usually weigh several thousand pounds. For the lighter works a single man is sufficient to hold, heat, and turn with one hand, whilst he hammers with the other.

FORISFAMILIATION, in *Law*. When a child, upon receiving a portion from his father, or otherwise, renounces his legal title to any further share of his father's succession, he is said to be *forisfamiliated*.

FORK, a well-known instrument, consisting of a handle and blade, divided at the end into two or more points or prongs. The *table-fork* did not come into use in England till the reign of James I., as we learn from a remarkable passage in Coryat. The reader will probably smile at the solemn manner in which this important discovery or innovation is related: "Here I will mention a thing that might have been spoken of before in discourse of the first Italian townes. I observed a custom in all those Italian cities and townes through the which I passed, that is not used in any other country that I saw in my travels, neither do I thinke that any other nation of Christendome doth use it, but only Italy. The Italians, and also most strangers that are commorant in Italy, doe always at their meals use a little forke when they eat their meate; for while with their knife, which they hold in one hand, they cut the meate out of the dish, they fasten the forke, which they hold in the other hand, upon the same dish, so that whatsoever he be that sitting in the company of any others at meale shall unadvisedly touch the dish of meat with his fingers from which all the table doe cut, he will give occasion of offence unto the company as having transgressed the lawes of good manners, insomuch that for his error he shall be at least browbeaten, if not reprehended in wordes. This form of feeding I understand is generally used in all parts of Italy, their forkes for the most part being made of yronn, steele, and some of silver, but those are used only by gentlemen. The reason of this their curiosity is, because the Italian cannot by any means indure to have his dish touched with fingers, seeing all men's fingers are not alike cleane. Hereupon I myself thought good to imitate the Italian fashion by this forked cutting of meate, not only while I was in Italy, but also in Germany, and often times in England since I came home: being once quipped for that frequently using my forke, by a certain learned gentleman, a familiar friend of mine, Mr Lawrence Whitaker, who in his merry humour doubted not to call me a table *furcifer*, only for using a forke at feeding, but for no other cause."

FORLI, one of the delegations of the papal dominion, in Italy, 1232 square miles in extent. It contains six cities, nineteen market-towns, and a great number of villages, with 150,930 inhabitants. It extends from the foot of the Appennines to the sea-shore, and is watered by several streams descending from those mountains, one of which, but not accurately ascertained, is the celebrated Rubicon. On the sea-shore are many morasses which generate malaria, but the remainder of the province is tolerably healthy, and highly fertile. The chief city, of the same name, is situated on the Via Æmilia, between the rivers Mentone and Ronco. It contains nine parish churches, sixteen monasteries, and seven nunneries. The population is 15,520. It has fabrics of silks, refineries for salt and for sulphur, linen weaving, and wax bleaching. Long. 12. 18. 5. E. Lat. 44. 13. 25. N.

FORLIMPOPOLI, an open city of the delegation Forli, in the papal dominions, in Italy, which, united with Bertinoro, forms a bishopric. It contains 5806 inhabitants.

FORLORN HOPE, in the military art, signifies men detached from several regiments, or otherwise appointed, to make the first attack in day of battle; or, at a siege, to storm the counterscarp, mount the breach, or the like. They are so called from the great danger to which they are unavoidably exposed.

FORM, in *Physics*, denotes the manner of being peculiar to each body; or that which constitutes it such a particular body, and distinguishes it from every other. But Mr Harris uses the term *form* in another sense, as an efficient animating principle; to which he supposes Ovid to refer in the first lines of his Metamorphoses.

> *In nova fert animus mutatas dicere* formas,
> *Corpora.*

These animating forms are not of themselves objects either of the ear or of the eye; but their nature or character is understood in this, that were they never to exert their proper energies on their proper subjects, the marble on which the sculptor exercises his art would remain for ever shapeless, and the harp from which the harper calls forth sounds would remain for ever silent.

Substantial forms seem to have been first broached by the followers of Aristotle, who thought matter, under different modes or modifications, not sufficient to constitute different bodies, but that something substantial was necessary to set them at a greater distance, and thus introduced substantial forms, on the footing of souls, which specify and distinguish animals. What led to this erroneous notion were the circumstances of life and death. For observing that, as soon as the soul had departed out of a man, all motion, respiration, nutrition, and other animal functions, immediately ceased, they concluded that these functions depended on the soul, and consequently that the soul was the form of the animal body, or that which constituted it such; indeed nobody doubted that the soul was a substance independent of matter; and hence it was concluded that the forms of other bodies were to be equally substantial. But to this it is answered, that though the soul be that by which man is man, and consequently the form of the human body as human, yet it does not follow that it is properly the form of this body of ours, as it is a body, or of the several parts thereof, considered as distinct from one another. For those several parts have their proper forms so closely connected with their matter, that it remains inseparable therefrom long after the soul has quitted the body; thus flesh has the form of flesh, bone of bone, and so forth, long after the soul is removed, as well as before. The truth is, the body does not become incapable of performing its accustomed functions because the soul has deserted it; but the soul takes its leave because the body is no longer in a condition to perform its functions.

The ancient and modern corpuscular philosophers, therefore, with the Cartesians, exclude the notion of substantial forms, and show, by many arguments, that the form is only the *modus* or manner of the body in which it is inherent. And as there are only three primary modes of matter, figure, rest, or motion, with two others arising therefrom, magnitude and situation, the form of all bodies they hold to consist in these modes, and suppose the variations which they are capable of sufficient to present all the variety observable in bodies.

Forms are usually distinguished into *essential* and *accidental.* Though the five modes above mentioned, generally taken, be adventitious, yet to this or that body, as to fire or water, they are *essential.* Thus it is *accidental* to iron to have this or that magnitude, figure, or situation, since it might exist in different ones; yet to a knife or hammer, the figure, magnitude, and position of parts, which constitute it a hammer or knife, are essential, and they cannot exist or be conceived without these. Hence it is inferred, that though there be no substantial, yet there are essential forms, by which the several species of bodies become what they are, and are distinguished from all others. *Accidental* forms are those really inherent in bodies, but in such manner as that the body may exist in all its perfection without them; such as whiteness in a wall, heat in water, a figure of a man in wax, and so on.

Form, in carpentry, is used to denote the long seats or benches in the choirs of churches or in schools, for the priests, prebends, religious persons, or scholars, to sit on. Du Cange supposes the name to be derived from this, that the backs of the seats were anciently enriched with figures of painting and sculpture, called in Latin *formæ et typi.* In the life of St William of Roschild, we meet with *forma* as signifying a seat for an ecclesiastic, or religious person, in a choir; and in that of St Lupicin, we find *formula* used in the same sense. In the rule of the monastery of St Cæsarea, the man who presides over the choir is called the occupant of the first form or seat.

FORMALITY, as defined in the schools, is any manner in which a thing is conceived; or a manner in any object, importing a relation to the understanding by which it may be distinguished from another object. Thus animality and rationality are formalities. The Scotists made great use of formalities, in opposition to the virtualities of the Thomists.

Formalities, in matters of law, are frequently used for the formulas themselves, or the rules prescribed for judicial procedure. In contracts of strict law all the formalities must be strictly observed, as an omission of the least may ruin the whole convention.

FORMAN, Andrew, archbishop of St Andrews, Earl of Pittenweem, and of Cottingham in England, one of the lords of the regency appointed by the states during the minority of King James V. of Scotland, legate *a latere*, primate of all the kingdom of Scotland, and archbishop of Bourges in France, was descended from the family of the Formans of Hutton in the county of Berwick, and is considered as having been one of the best statesmen of the age in which he lived. He was employed in 1501, along with Robert Blackader, archbishop of Glasgow, and Patrick earl of Bothwell, to negotiate a match between James IV. of Scotland, and Margaret eldest daughter of Henry VII. of England, which next year was ratified by the Scottish ambassadors. He was afterwards frequently employed as Scottish ambassador to Rome, England, and France, upon the most important occasions. In 1514 he was translated from the see of Moray, to which he had been appointed in 1502, to that of St Andrews. During the time he possessed the former, he was employed as mediator between Pope Julius II. and Louis XII. of France, who were at that time at variance; and he happily succeeded in conciliating the difference. Having taken leave of the pope, he on his return home passed through France, where he was kindly received by the king and queen, who bestowed upon him the bishopric of Bourges in France, which brought him annually 400 tuns of wine, 10,000 francs of gold, and other smaller matters. Besides this, he was most liberally rewarded by Pope Julius, who promoted him to the archbishopric of St Andrews, as has been already mentioned, conferred on him the two rich abbeys of Dunfermline and Aberbrothick, and made him his legate *a latere*. At that time, however, there were two other candidates for the archiepiscopal see. The learned Gavin Douglas, bishop of Dunkeld, having been nominated by the queen, had actually taken possession; but John Hepburn, a bold and factious man, having been preferred by the monks, drove out the officers of Gavin Douglas, and placed a strong garrison in the castle. And so great was the power of this man, that when Forman was nominated by the pope, no person could be found to proclaim the bulls for his election. At last Lord Home, at that time the most powerful nobleman in Scotland, was induced, by large promises, besides some considerable gifts, amongst which was the donation of the abbacy of Coldingham to his youngest brother David, to undertake the task. It was executed at Edinburgh and at St Andrews, to which places Lord Home's brother proceeded with 10,000 men; though the doing of it, contrary to Forman's inclination, proved a source of much trouble to that nobleman afterwards. The quarrel between Hepburn and Forman, however, was at last terminated by the latter surrendering the bishopric of Moray, as well as some years' revenue of the archbishopric itself, and paying Hepburn three thousand French crowns annually out of his ecclesiastical revenues. On the appointment of the Duke of Albany to the regency, Hepburn endeavoured to undermine the primate's credit with that nobleman, by representing him as one who had in a manner collected all the money in the country, and who consequently might endanger the tranquillity of the kingdom. These insinuations, however, were but little regarded by the regent; and Forman had the good fortune afterwards to compose a difference between him and the nobility, which was likely to be attended with bloodshed. In 1517 the archbishop was appointed by the states one of the lords of the regency, on the occasion of the Duke of Albany's going to France. His embassy to Pope Julius II. has been already mentioned. In Mackenzie's Lives we are informed, that in the collection of the Letters of the Scottish Kings from the year 1505 till the year 1626, in the Advocates' Library, there is a letter from the pope to King James IV., in which he not only commends Forman highly, but likewise promises that at the first creation of cardinals he should be made one. This letter is dated the 6th of May 1511; but the pope died before he had an opportunity of performing his promise. In the same collection there is a letter from the Duke of Albany to Leo X., successor of Julius, in which he urges the pope to advance Forman to the dignity of a cardinal, promised him by his predecessor, and to continue him as legate *a latere*. Archbishop Forman died in the year 1521, and was buried at Dunfermline. Dempster says that he wrote a book against Luther, a book concerning the Stoical philosophy, and a collection out of the Decretals.

FORMATION, in *Philosophy*, an act by which something is formed or produced.

FORMATION, in *Geology*. See MINERALOGY.

FORMATION, in *Grammar*, signifies the manner of forming one word from another. Thus *accountantship* is formed from *accountant*, and this last from *account*.

FORMEDON, in *Law* (*breve de forma donationis*), a writ that lies for a person who has a right to lands or tenements, by virtue of any entail, arising from the statute of Westminster.

FORMENTERA, one of the Balearic Islands, in the Mediterranean Sea, belonging to the crown of Spain. It lies to the south of Iviça, is twelve miles in length, in some parts eight miles, and in others, from great indentations, not more than half a mile in breadth. Its name is derived from the abundant crops of wheat which are produced on the western part of the island, whilst the eastern part is almost wholly covered with thick woods. There is no town on the island; but it is peopled by 1500 inhabitants, who live in villages or sequestered cottages. It is separated from Iviça by a strait two miles across, in the middle of which is the small island Espalmado.

FORMICA, the ANT. See ENTOMOLOGY.

FORMING is used for the act of giving being or birth to any thing. The word is also simply used for giving figure to any thing. The potter forms his vessels as he pleases. Geometry teaches how to form all kinds of figures.

FORMING *of a Siege*, is the making lines of circumvallation, to fortify the camp, and disposing things for the attack of a place in form.

FORMING *the Line*, is drawing up infantry, cavalry, and artillery, in order of battle.

FORMING is also used in grammar, in speaking of certain tenses of verbs, which are made from others by a change of certain letters. The present tense is formed from the infinitive. Compound and derivative words, also, and even all that have any etymology, are said to be formed.

FORMOSA, a large island in the Eastern Seas, more properly called Tywan. It is about 180 miles in length by 50 in breadth, is distant 100 miles from the south-east coast of China, and lies between the twenty-third and twenty-sixth degrees of north latitude. The Dutch at an early period established a settlement on this island; and it was long subject to their authority. In 1625 the viceroy of the Philippine Islands sent an expedition against Formosa, with a view to expel the Dutch, and to propagate the Roman Catholic religion in the island. But after erecting fortifications, the Spaniards abandoned the island. About the middle of the seventeenth century it afforded a retreat to 20,000 or 30,000 Chinese, from the fury of the Tartar conquest. These refugees were, according to the usual habits of the Chinese, very industrious; and they carried on a lucrative trade with their countrymen in China, which proved the source of an abundant revenue to the Dutch government. A profitable trade was also carried on by the Dutch with Japan. In 1653 a conspiracy of the Chinese inhabitants against the Dutch was discovered and suppressed; and soon after this, Coxinga, the governor of the maritime Chinese province of Tehichiang, applied for permission to retire to the island, which was refused by the Dutch governor; on which he fitted out an expedition consisting of 600 vessels, and made himself master of the town of Formosa and the adjacent country, and afterwards besieged and took Fort Zealand, when the Dutch were all allowed to embark and leave the island. The loss of this convenient station and entrepôt of trade was severely felt by their East India Company. Coxinga afterwards engaged in a war with the Chinese and the Dutch, in which he was defeated and slain. But they were not able to obtain possession of the island, which was bravely defended by the posterity of Coxinga; and it was not till the year 1683 that the island was voluntarily surrendered by the reigning prince to the emperor of China, and it has ever since remained in possession of the Chinese. In 1676 the English had a factory at Formosa, the chief object of which was to carry on a trade with Japan. In 1805, through the weakness of the Chinese government, the Ladrone pirates had acquired possession of a great part of the south-west coast of Formosa.

FORMULA, or FORMULARY, a rule or model, or certain terms prescribed or decreed by authority, for the form and manner of an act, instrument, proceeding, or the like.

Forres.

Formula, in *Ecclesiastical History* and *Theology*, signifies a profession of faith.

Formula, in *Medicine*, imports the constitution of medicines, either simple or compound, both with respect to their prescription and their consistence.

Formula, a theorem or general rule or expression, for solving certain particular cases of some problem; so $\frac{1}{2}s + \frac{1}{2}d$ is a general formula for the greater of two quantities whose sum is s, and difference d; and $\frac{1}{2}s - \frac{1}{2}d$ is the formula or general value for the less quantity. Also $\sqrt{dx - x^2}$ is the formula or general value of the ordinate to a circle whose diameter is d and absciss x.

FORMULARY, a writing containing the form or formula of an oath, declaration, attestation, or abjuration, to be made on certain occasions. There are also formularies of devotion, of prayers, and the like. Liturgies are formularies of the public service in most churches.

FORNACALIA, or **Fornicalia**, in Roman antiquity, a festival instituted by Numa, in honour of Fornax, the goddess of ovens, in which certain cakes were made, and offered in sacrifice before the ovens.

FORNICATION (*fornicatio*, from the *fornices* in Rome, where the lewd women prostituted themselves for money), the act of incontinency between single persons. Upon this subject we find the following observations in Paley's *Moral and Political Philosophy*:—

"The Scriptures give no sanction to those austerities which have been since imposed upon the world under the name of Christ's religion, as the celibacy of the clergy, the praise of perpetual virginity, the *prohibitio concubitus cum gravida uxore*; but, with a just knowledge of, and regard to, the condition and interest of the human species, have provided in the marriage of one man with one woman an adequate gratification for the propensities of their nature, and have restrained them to that gratification.

"The avowed toleration, and in some countries the licensing, taxing, and regulating of public brothels, has appeared to the people an authorizing of fornication, and has contributed, with other causes, so far to vitiate the public opinion, that there is no practice of which the immorality is so little thought of or acknowledged, although there are few in which it can more plainly be made out. The legislators who have patronized receptacles of prostitution ought to have foreseen this effect, as well as considered, that whatever facilitates fornication, diminishes marriages. And as to the usual apology for this relaxed discipline, the danger of greater enormities if access to prostitutes were too strictly watched and prohibited, it will be time enough to look to that after the laws and the magistrates have done their utmost. The greatest vigilance of both will do more than oppose some bounds and some difficulties to this intercourse. And after all, these pretended fears are without foundation in experience. The men are in all respects the most virtuous in countries where the women are most chaste.

"If fornication be criminal, all those incentives which lead to it are accessaries to the crime; as lascivious conversation, whether expressed in obscene or disguised under modest phrases; also wanton songs, pictures, books, the writing, publishing, and circulating of which, whether out of frolic or for some pitiful profit, is productive of so extensive a mischief from so mean a temptation, that few crimes within the reach of private wickedness have more to answer for, or less to plead in their excuse."

FORNIX, in *Anatomy*, is a part of the *corpus callosum* in the brain, so called on account of a distant resemblance to the arch of an ancient vault when viewed in a particular manner.

FORQUALQUIER, an arrondissement of the department of the Lower Alps, in France, extending over 369 square miles. It is divided into six cantons and fifty-two communes, and contains 32,411 inhabitants. The capital is a town of the same name, situated on a plain through which the river Laye flows, and which yields wine, olive oil, and much silk. The latter is extensively spun there. It contains 2741 inhabitants. Long. 5. 46. E. Lat. 43. 58. N.

FORRES, a royal burgh of Scotland, in the county of Moray. It stands on a rising ground, at the distance of three miles from the mouth of the Findhorn, and is neat and well built. The trade carried on here is not very extensive; amongst other articles, straw plait for bonnets is manufactured. In this town there is a fine stone building, called Anderson's Institution, which was founded in 1824. Here the youth of Forres, Rafford, and Kinloss, are taught the classics, mathematics, natural philosophy, and other branches of education. Besides this academy there are several private schools in Forres; and a news-room, a subscription library, and various friendly societies. The places of worship are the parish church, a meeting-house of the United Secession church, and another of the Independents. At the western extremity of the town is an eminence on which stood the castle of Forres. This is an object of curiosity; for here Duffus, one of the early kings of Scotland, was killed by Donwald, governor of the castle. The river Findhorn runs immediately behind the eminence. At this place a very handsome bridge was swept away by the great flood of August 1829, which will be noticed in the article Morayshire. Forres is noted for the possession of one of the most remarkable ancient stone obelisks to be found in Britain. It is thus described by Mr Cordiner, in a letter to Mr Pennant: "In the first division, underneath the Gothic ornaments at the top, are nine horses with their riders marching forth in order. In the next is a line of warriors on foot, brandishing their weapons, and appear to be shouting for the battle. The import of the attitudes in the third division is very dubious, their expression indefinite. The figures which form a square in the middle of the column are pretty complex, but distinct; four serjeants with their halberts guard a canopy, under which are placed several human heads which have belonged to the dead bodies piled up at the left of the division; one appears in the character of executioner severing the head from another body; behind him are three trumpeters sounding their trumpets, and before him two pair of combatants fighting with sword and target. A troop of horse next appears, put to flight by infantry, whose first line have bows and arrows, the three following swords and targets. In the lowermost division now visible, the horses seem to be seized by the victorious party, their riders beheaded, and the head of their chief hung in chains or placed in a frame; the others being thrown together beside the dead bodies under an arched cover. The greatest part of the other side of the obelisk, occupied by a sumptuous cross, is covered over with an uniform figure, elaborately raised, and interwoven with great mathematical exactness. Under the cross are two august personages, with some attendants, much obliterated, but evidently in an attitude of reconciliation; and if the monument was erected in memory of the peace concluded between Malcolm and Canute, upon the final retreat of the Danes, these large figures may represent the reconciled monarchs. On the edge below the fretwork are some rows of figures joined hand in hand, which may also imply the new degree of confidence and security which took place, after the feuds were composed, which were characterized on the front of the pillar. But to whatever particular transaction it may allude, it can hardly be imagined that, in so early an age of the arts in Scotland as it must have been raised, so elaborate a performance would have been undertaken but in consequence of an event of the most general importance; it is therefore surprising that no distincter traditions of it arrived at the era when letters were known. The height of this monument (called *King Sueno's Stone*) above the ground is twenty-three feet, besides twelve or fifteen feet under ground. Its breadth is three feet ten inches by one foot three inches in thickness."

FORSTER, John Reinhold, a celebrated naturalist and geographer, and an accomplished scholar and linguist, was born on the 22d October 1729, at Dirschau, in Polish Prussia, where his father was burgomaster or mayor. His family was of English descent, and had quitted Great Britain in the time of Charles I.

At the age of fourteen he was placed for a year at the public school of Marienwerder, and was afterwards admitted into the gymnasium of Joachimsthal at Berlin. Among his schoolfellows was Pallas, who became so well known for his various researches in natural history, with several others who distinguished themselves in literature and science. He applied himself with diligence to the study of the ancient and modern languages, and in particular of the oriental languages, as connected with divinity. He continued the same pursuits at the university of Halle, which he entered in 1748. After three years, having completed his theological studies, he resided for two years more at Dantzick, preaching as a candidate. In 1753 he obtained a small benefice at the neighbouring town of Nassenhuben, and the next year he married his cousin Elizabeth Nikolai; but he still found leisure to improve himself in natural philosophy, geography, and the mathematics. His increasing family having become too expensive for his income, he accepted the proposals of the Russian consul at Dantzick, and agreed to superintend the establishment of the new colonies at Saratof on the Volga. The consul received the thanks of the reigning favourite, Count Orlof, for his judicious selection of a person so well qualified; but our adventurer was not satisfied with his success in the undertaking, and, in 1766, he resolved, somewhat suddenly, to try his fortune in England, whither he proceeded well recommended, but with exhausted finances. Soon afterwards, however, he received a gratuity of 100 guineas from the Russian government, and he obtained some remuneration from the booksellers for his translations from the German and the Swedish. He declined a proposal of Lord Baltimore, who offered him the management of his large estates in America, preferring the appointment of a teacher of modern languages and natural history in the dissenting academy of Warrington, where he found a more interesting society than would have been attainable in any part of the New World. He was not, however, very popular as an instructor; and he was soon after this engaged to accompany Mr Dalrymple, who was going out as governor of Balambanjan, near Borneo; but the plan was never executed. In 1772 he was appointed naturalist to the expedition under the command of Captain Cook in his second voyage of circumnavigation; and he took with him his son George, then seventeen years old. For this undertaking Forster was abundantly qualified as a man of science and an accurate observer, though his temper and conduct were not always such as to make him agreeable to his shipmates, nor was he uniformly considerate and humane in his intercourse with the uncivilized inhabitants of the countries which he explored. After the return of the expedition, there were repeated discussions and disputes respecting Forster's share in the intended publication of the narrative of the voyage. Two thousand pounds, which had been granted by government for the plates of the work, were to have been equally divided between Cook and Forster for this purpose; but Forster's performance of his part of the undertaking was disapproved, and he was deprived of the advantage which he expected to have derived from the plates. It is possible that he may have expressed himself incautiously respecting the conduct of the expedition; perhaps also he may have been thought deficient in accuracy of idiom; for he was more fluent than correct or elegant in the various languages which he was in the habit of speaking and writing. He was, however, supposed to be concerned in the account of the voyage which was published by his son; and this participation was considered by his opponents, and even by many of his friends, as an infringement of the conditions of his engagement; besides that many offensive remarks and a few inaccuracies were introduced into the work, some of which were afterwards candidly admitted and corrected by his son. All these circumstances made Forster's residence in England by no means agreeable, and his pecuniary embarrassments became so pressing that he was at one time in confinement for debt. He was, however, set at liberty in 1780, by the munificence of the king of Prussia, who furnished him with the means of satisfying his creditors, and established him at Halle, as professor of natural history, and inspector of the botanical garden. The year after he took the degree of doctor of physic in the university. He was not always on the most cordial terms with his academical colleagues, and he was too fond of accusing them in his reports to his superiors. His circumstances were also much embarrassed by his unfortunate propensity to play, which absorbed the whole earnings of his labour. He, however, considered the eighteen years that he spent at Halle as the happiest of his life. He was much afflicted in his old age by the premature death of his two sons; indeed his health seemed to be impaired by his grief, and he died on the 9th December 1798. Professor Kurt Sprengel has written an account of his life, containing a just encomium on his various talents and acquirements, though somewhat too flattering with regard to his moral character. He appears to have been master of seventeen different languages; and he was as extensively acquainted with things as with words, being as much indebted for his various knowledge to his industrious and accurate observation of nature, as to his great reading and his profound learning. He was long intimate with Buffon, and greatly admired his writings; and he was in constant correspondence with Linnæus and his son, the latter of whom gave the name of *Forstera* to a new genus of plants, in compliment to the two botanists who had discovered it in New Zealand. In conversation he was witty, but frequently too satirical; and his unguarded sallies created him many enemies. He became a fellow of the Society of Antiquaries soon after his arrival in England; in February 1772 he was elected a fellow of the Royal Society; and in 1775, upon his return from the South Seas, the university of Oxford conferred on him the honorary diploma of a doctor of laws. His principal publications are these:

1. *Specimen Historiæ Naturalis Volgensis, Phil. Trans.* 1767, p. 312, containing a geographical description of the country about Saratof, and an ample enumeration of its various productions. 2. *An Introduction to Mineralogy, or an accurate Classification of Fossils and Minerals*, 8vo, London, 1768; with a *Translation of* Lehman's *Halotechnia*, intended principally as a text-book for a course of lectures delivered at Warrington. 3. *A Catalogue of British Insects*, 8vo, Warrington, 1770. 4. *A Translation of* Kalm's *Travels into North America*, 3 vols. 8vo, Warrington and London, 1770, 1771. 5. Osbeck's *Voyage to China and the East Indies, translated from the German; with a Faunula and Flora Sinensis*, 2 vols. 8vo, London, 1771. 6. *A Translation of* Bossu's *Travels in Louisiana, with Notes, and a Systematic Catalogue of all the known Plants of English North America; together with an Abstract of* Löfling's *Travels*, 2 vols. 8vo, London, 1771. 7. *Novæ Species Insectorum*, Centuria 1, 8vo, London, 1771; consisting chiefly of English insects, together with a few foreign

ones, arranged according to the Linnæan system, with the adoption of two genera from Geoffroy. 8. *An Account of the management of Carp in Polish Prussia, Ph. Tr.* 1771, p. 310, in a letter to the Honourable Daines Barrington. It appears that the carp is a kind of staple commodity of that country. 9. *An Easy Method of Assaying and Classing Mineral Substances, with a Translation of* Schecle's *Experiments on Sparry Fluor, from the Memoirs of the Swedish Academy*, 8vo, London, 1772. 10. *Translation of* Bougainville's *Voyage*, 4to, London, 1772. 11. *Epistolæ ad* J. D. Michaelis, 4to, Göttingen, 1772, containing remarks on this author's *Spicilegium Geographiæ Exteræ*. 12. *An Account of the Roots used by the Indians in the neighbourhood of Hudson's Bay to dye Porcupines' Quills, Phil. Tr.* 1772, p. 54; the Galium tinctorium and Helleborus trifolius. 13. *An Account of several Quadrupeds from Hudson's Bay, Phil. Tr.* 1772, p. 370; describing a collection of specimens sent to the Royal Society from the Factory at Hudson's Bay. 14. *An Account of the Birds sent from Hudson's Bay,* p. 382. 15. *An Account of some Curious Fishes sent from Hudson's Bay, Phil. Tr.* 1773, p. 149, addressed to T. Pennant, Esq. These papers were published during the author's absence with Captain Cook. 16. 17. He translated Grainger's *Travels* and Riedesel's *Travels*, in conjunction with his son George. 18. He made a *Catalogue of the Animals and Plants represented in Catesby's Carolina, with the Linnæan names.* 19. *Characteres generum plantarum, quas in itinere ad insulas maris australis collegerunt* J. R. et G. Forster, folio, London, 1776, containing descriptions and figures of 75 new genera. 20. *Liber singularis, de Bysso antiquorum, quo ex Ægyptiaca lingua res vestiaria antiquorum, imprimis in sacro codice occurrens explicatur*, 8vo, London, 1776. The object of this essay is to prove that the *byssus* of the ancients was cotton, and not fine linen, in which the author succeeds without difficulty; and he states, that all the cloths enveloping the mummies that he has been able to examine are uniformly cotton. In his Egyptian etymologies he is learned and ingenious, but, like almost all other Egyptian etymologists, extremely precipitate. 21. *Observations made during a Voyage Round the World, on Physical Geography, Natural History, and Ethic Philosophy, especially on the Earth and its Strata, Water, and the Ocean, the Atmosphere, the Changes of the Globe, Organic Bodies, and the Human Species*, 4to, London, 1778. This highly interesting work was published by subscription; and a French translation of it was added as a fifth volume to that of Cook's Voyage, 4to, Paris, 1778. 22. *Description of the Yerbua Capensis, Swed. Trans.* 1778, p. 108. 23. *Translation of* Von Troil's *Letters on Iceland*, 8vo, London, 1780. 24. *On* Buffon's *Epochs of Nature, Göttingen Mag.* 1780, i. i. p. 140. 25. *On the Tiger-Cat of the Cape, Phil. Trans.* 1781, p. 1; the Felis Capensis, found from Congo to the Cape, and capable of being tamed like a cat. 26. *Historia Aptenodytæ, Commentat. Gott.* vol. iii. p. 121; the penguin, a genus peculiar to the southern hemisphere. 27. *Zoologia Indica Selecta*, Latin and German, fol. Halle, 1781, 4to, London, 1790; 2d edit. Halle, 1795. 28. *Account of a New Insect, Naturforscher*, vol. xvii. p. 206, Halle, 1782; a species of cancer. 29. *A Picture of England for* 1780, *continued to* 1783, 8vo, 1784; German, 8vo, Dessau, 1784; giving some amusing particulars of many of the principal public characters at the time of the American war, but frequently satirical, and sometimes unjust. 30. *Essays on Moral and Physical Geography*, 3 vols. 8vo, Leipsic, 1781, 1783; continued by his son-in-law Matthias Sprengel. 31. *A Collection of Memoirs relating to Domestic Economy and Technology*, 8vo, Halle, 1784. 32. *On the Albatross, Mém. Sav. Etr.* vol. x. p. 563; the Diomedea. 33. *History of Discoveries and Voyages in the North*, 8vo, Francfort on the Oder, 1784; English, London, 1786, Fr. Paris, 1788; containing a most extensive and elaborate collection of relations of all the attempts which had been made to explore the arctic regions. 34. *Project for abolishing Mendicity, especially at Halle*, 8vo, Halle, 1786. 35. *Enchiridion Historiæ Naturali inserviens*, 8vo, Halle, 1788; an extremely useful collection of definitions of the terms employed in the description of birds, fishes, insects, and plants, after the manner of the *Philosophia Botanica* of Linnæus; it is dedicated to his son George, by whose infantine curiosity he was first impelled to the study of natural history; and it was chiefly arranged during the leisure hours of his voyage round the world. 36. *A Memoir on the Badjar Cit. Mém. Acad. Berl.* 1788, 1789, p. 90; the Manis pentadactylus. 37. *Magazine of Modern Voyages and Travels, translated from various languages, with Remarks*, 16 vols. 8vo, Halle, 1790, 1798. 38. An edition of *Bergius über die Leckereyen*, a work on diet, with notes by Forster, Kurt, and Sprengel, 2 vols. 8vo, Halle, 1792. 39. *A Letter to Schreber on the Persea, Magazin für die Botanik*, vol. v. p. 234. 40. *Onomatologia nova systematis oryctognosiæ vocabulis Latinis expressa*, folio, Hal. 1795, 1 page. 41. *Observations and Truths united to Probabilities, or Materials for a new Essay on the Theory of the Earth*, 8vo, Leipzig, 1798; one of the last of our author's publications, which is considered as a good elementary work on geology.

(Sprengel's *Memoir;* Eyries in *Biographie Universelle*, vol. xv. 8vo, Paris, 1816; Aikin's *General Biography*, vol. iv. 4to, London, 1803; Chalmers's *Biographical Dictionary*, vol. xiii. 8vo, London, 1814.) (L. L.)

FORSTER, *John George Adam*, commonly called *George*, a distinguished naturalist and circumnavigator, the son of John Reinhold Forster, was born at Dantzick in 1754, and enjoyed, in his earliest youth, the advantage of his father's assiduous and affectionate instructions, by which he profited so rapidly, that he was capable, at the age of ten years, when he went with his father into Russia, of ascertaining the species of a plant by comparing it with the Linnæan description. He was for a short time at a school in Petersburg. Upon his arrival in London, he was at first placed in a merchant's counting-house, but soon found his health unequal to the employment, and followed his father to Warrington, where he continued his studies at the academy with so much application, that he became a perfect master of the English language, and otherwise distinguished himself by the strength of his memory and the vigour of his imagination, at the same time that he assisted his father in giving lessons in French, and in completing a variety of translations of voyages and travels. He also accompanied his father, together with Sparrman, in the arduous engagement of making all kinds of physical observations in the circumnavigation of the globe; and he was particularly employed in delineating the various objects of natural history which were discovered. After his return he was elected a fellow of the Royal Society; but he soon quitted England to settle at Paris. In 1779, however, he was appointed professor of natural history at Cassel; and, in 1784, he was nominated to a similar situation in the University of Wilna, where he took a degree of doctor of physic; but he found little satisfaction in residing amongst a people so imperfectly civilized. The empress of Russia had engaged him to take an important part in a new voyage of discovery which she meditated; but the design was abandoned upon the commencement of the war with the Turks. He was next invited by the elector of Mentz to accept the appointment of president of the university newly established in that city, and he was residing there at the time when the French army entered it. Being a declared republican in his political principles, he was dispatched as an envoy to Paris to solicit the incorporation of Mentz with the French republic; but during his absence the Prussian troops retook the city, and he lost the whole of his property, including his numerous manuscripts. He had married a Miss Theresa Hayne, and had one daughter as early as 1788; but, at a subsequent period, his wife's conduct gave him great reason for uneasiness; and though he affected to despise what he called the prejudices of social life, and to excuse her infidelity, and even attempted to facilitate her union with a more favoured admirer, still the affair in reality affected him deeply, and he resolved once more to leave Europe, as if in search of the waters of oblivion; and he was actually preparing for a voyage to Thibet, when his health was subdued by the ravages of a scorbutic disorder, and he died on the 13th February 1792. Besides the assistance which he rendered his father in many of his literary undertakings, he was also the author of a variety of separate publications under his own name.

1. *A Voyage Round the World in his Britannic Majesty's Ship Resolution, commanded by* Captain James Cook, *during the years* 1772, 1773, 1774, and 1775, 2 vols. 4to, London, 1777; in German, 2 vols. 4to, Berlin, 1779, 1780, and 3 vols. 8vo, 1784. The style of this work is rather more animated and poetical than that of the official account of the voyage; the second volume is considered as the best written, and the freest from affectation and false sentiment. 2. Mr Wales, the astronomer of the expedition, published some remarks on the work, which occasioned a *Reply to* Mr Wales's *Remarks*, 8vo, London, 1778, in which the author declares that his father had no concern whatever in the book, but he admits that he had committed some inaccuracies. 3. *A Letter to the* Earl of Sandwich, 4to, London, 1779. 4. His *Answer to the Authors of the Literary Journal of Göttingen* exhibits considerable warmth of language, but candidly admits some errors; it excited some further animadversions from Professor Meiners, who declared himself the author of the criticisms. 5. In 1787 he published at Berlin, in 4to, *A Translation of* Captain Cook's *Third Voyage, performed in* 1776–1780, with an introduction and other additions. 6. *A Description of the Gentiana saxosa, Swedish Trans.* 1777, p. 183. 7. *Life of* Dr Dodd, 8vo, Berlin, 1779. 8. *Preface to* Sparrman's *Travels,* 8vo, Berlin, 1784. 9. He undertook, together with Professor Lichtenberg, the publication of the *Göttingen Magazine,* which was continued from 1780 to 1785, and published in it, amongst other essays, *A Description of the Red Creeper, or Certhia coccinea of Owhyhee,* i. vi. p. 346. 10. *Experiments with Vital Air,* vol. iii. ii. p. 281; examining its effects on glow-worms. 11. *A Decad of New Plants,* N. Act. Upsal, vol. iii. 1780, p. 171. 12. *On Pygmies,* Hessiche Beyträge, vol. i. p. 1, 1785. 13. *History and Description of the Bread-Fruit Tree,* p. 208, 384; also separately, 4to, Cassel, 1784. 14. *Florulæ Insularum Australium Prodromus,* 8vo, Göttingen, 1786. 15. *Fasciculus Plantarum Magellanicarum,* Commentat. Soc. Gött. vol. ix. p. 13. 16. *Plantæ Atlanticæ,* p. 46. 17. *Miscellanies, or Essays on Moral and Physical Geography, Natural History, and Moral Philosophy,* 6 vols. 8vo, Leipsic and Berlin, 1789–1797; the last two volumes are posthumous, and chiefly of a political nature. 18. *Picture of the Lower Rhine, Brabant, Flanders, Holland, England, and France,* taken in the year 1790, 3 vols. 8vo, Berlin, 1791–1794; Dutch, Haarlem, 1792, 1793; French, called *Voyage Philosophique,* 2 vols. 8vo, Paris, 1795, 1796. This work contains many interesting remarks on manners and on the arts, showing that the author possessed very extensive information, as well as originality of talent; but there is too much affectation of sentiment, and an injudicious display of hostility to Great Britain. 19. *Historical Remembrances of the Year* 1790, 8vo, Berlin, 1793. There are also several political pamphlets of a temporary nature, which could add little or nothing to their author's fame; and a few scattered memoirs in different periodical publications. He was also concerned in the *Collection of Voyages* published by Professor Sprengel; and, together with Pallas and others, in an edition of Martini's *Dictionary of Natural History.* Indeed, his life, though short, was one continued scene of literary activity; but his application to the labour of compilation was too unremitting to allow him to concentrate the whole force of his mind on the performance of any one great original work of genius. The *Sketches of the Mythology and Customs of the Hindoos* were written by another author of the same name.

(*Life* by Pougens; J. R. Forster in *Jacobi's Annals,* and in the *Dedication of his Enchiridion;* Eyries in *Biographie Universelle,* vol. xv. 8vo, Paris, 1816; Aikin's *General Biography,* vol. iv. 4to, London, 1808; Chalmers's *Biographical Dictionary,* vol. xiii. 8vo, London, 1814.) (L. L.)

FORT, in the military art, a small fortified place, environed on all sides with a ditch, rampart, and parapet. Its use is to secure some high ground, or the passage of a river, to make good an advantageous post, to defend the lines and quarters of a siege, and the like. Forts are made of different figures and dimensions, according as the peculiar nature of the ground requires. Some are provided with bastions, others with demi-bastions; some are of a square form, others pentagonal, and others again are stellated, having five or seven angles. A fort differs from a citadel in this, that the latter is built to command some town.

Vitrified FORTS. This name has been given to certain remarkable ruins, situated for the most part on the tops of certain hills in the Highlands and northern parts of Scotland. They were first discovered about the year 1773, by Mr Williams, an intelligent mineral surveyor, who published an account of them some time afterwards. These singular structures derive their appellation of vitrified from the circumstance of the stones composing them presenting the appearance of having been melted or fused by means of fire, thus forming a solid mass of a glassy structure, somewhat resembling volcanic lava, or the refuse of a furnace. The single fact of their vitrification is the only characteristic applicable in a general sense to the whole of these forts. In form, size, and situation, they present every variety. Some of them are round or elliptical, whilst others are in the form of squares or parallelograms. In magnitude they vary from a few yards to some eighty or ninety in length, whilst their breadth differs in a proportional degree. The walls, likewise, as might have been expected, vary much in thickness. Some of them are only two or three, and others are about twenty feet in breadth. In height they also differ considerably, having apparently in some instances been twelve feet, and in others not a third of that height. In one or two instances there are a series of walls, two or three in number, enclosing the same area of ground, with a space between each of the works sufficiently large to admit of active defensive operations on the part of those who occupied the place. Their vitrification is very irregular. Occasionally it does not extend a few feet above the ground on which the fabric stands, nor penetrate beyond the surface, whilst in a few instances it rises to the height of ten or twelve feet, and passes inwards to a considerable extent on both sides. Sometimes only isolated parts of the walls show traces of vitrification, and that too but on one side; in other instances the process appears to have been completed with elaborate care, as the effects of the heat extend externally and internally over the greater part of their surfaces. They are for the most part placed, not upon the highest elevation of the country where they are situated, but generally in a commanding position; and they are found sometimes upon the sea-shore, and sometimes many miles inland. In general their structure displays nothing like regular masonry; that is, the stones have not been hewn into symmetrical shapes and cemented together, as is the case in the more modern structures of the same country. A few of them have regular causeways leading up to them, and many are furnished with wells, an indispensable requisite for a garrison. Such is a general description of these singular erections, which have for more than half a century excited so much curiosity and interest.

After the discovery of Mr Williams, the ingenuity of the learned was turned to their probable origin, and several theories and conjectures were hazarded by various individuals upon the subject. By one party they were declared to be of volcanic origin, whilst another contended that they were works of art. Of the latter opinion was Mr Williams himself, who not only declared them to be the result of human ingenuity, but speculated upon the manner in which they were constructed. But before adverting to any of the theories which have been advanced, we shall give a description of the most remarkable of these forts, and this, as far as possible, in the language of those individuals by whom they were examined.

Dun MacSniochain, which lies in Argyleshire, is very fully described by Dr Macculloch.[1] "It is situated on a small rocky hill, which forms a kind of island in the plain, of a narrow prolonged shape, and scarped all round, except at one extremity, which affords access to the summit and the fort. The height of this hill or rock above the plain seems to be about forty or fifty feet; and it is, even in the modern military sense, a strong position. It is important to remark, that the rock consists of limestone and slate intermixed, the plain itself being chiefly alluvial, and the nearest hill and rocks being of trap, and of that puddingstone so well known to all travellers, which also abounds in the vicinity of Oban. That stone is itself formed of fragments of various trap rocks, and is remarkable for its ready fusibility, while the rock on which the fort stands is of an infusible nature. The fort itself is so contrived as to occupy nearly the whole summit, which is about 250 yards long, and consists of three distinct parallelogramic enclosures. The dimensions of these are as follows, as nearly as could be measured by pacing. The outer is about thirty yards long and about twenty-four broad; the next is about thirty-seven, with a similar breadth; and that at the farther extremity is about fifty-six yards in length, but being imperfect, it may formerly have been longer. Besides this, between the first and second works there is a transverse wall which reaches from the one precipitous face to the other, so as, when entire, to have cut off the communication from without to the two inner works. The circumferences of the two inner enclosures make collectively a line of about 260 yards, which, according to the modern military computation for a redoubt, would contain more than 500 men. The external work would dispose of about a hundred more. Hence it is plain that this must have been a military work of some consequence, as capable of holding a large garrison." The doctor goes on to show the eligibility of this place as one of military defence; and observes, that the walls were probably twelve feet thick. He continues, "when it is said that the walls here or elsewhere are vitrified, it must not be supposed that they form a solid mass of glass or slag. That condition is very various in different specimens throughout Scotland, and if it is here more perfect than in many, it is less so than in some others. To speak more accurately, many of the stones which form the walls are more or less perfectly slagged or scorified; so that while some have been thus changed throughout, the surfaces only of others are affected, while others again, consisting of less fusible materials, are only burnt. A certain proportion has escaped the fire altogether, or has never been exposed to it; and if we may judge from the ruins, this has taken place chiefly towards the upper part of the wall. The general result, however, is, that in some parts the wall forms a solid mass, but of an irregular composition, consisting of scoria, slag, burnt stones, and stones scarcely altered, united together, but with vacant intervals; while in other places it is separable into lumps of various sizes, and into single stones."

The next vitrified fort described by Dr Macculloch is that of Dunadeer.

"The hill of Dunadeer, having an elevation of about 600 feet[2] from the irregular plain on which it stands, with a steep acclivity all round, has a flat oval summit, which is entirely occupied by the enclosure, so as to form a strong military position. Though much ruined, and consequently obscured, having apparently been used as a quarry for building a more modern castle in the same spot, it is not difficult to trace either the dimensions or the disposition of the original work. The form is a parallelogram, of which one extremity is curved, so as to be nearly semicircular, and its longest side is about fifty-eight yards, the shortest being about twenty-four. The thickness of the wall seems originally to have been eighteen or twenty feet; although, from the state and nature of the ruin, it is impossible to be very accurate in this particular. The highest remaining portion is about six feet above the present surface; and if one foot be added for the increase of soil, and two for the loss which it has sustained at the summit, to be computed from the ruined part at its foot on each side, we shall have eight feet as the probable original altitude.

"The materials of the hill are chiefly grey granite, an infusible rock; but there are scattered in the surrounding plain blocks of a black variety, which, from containing hornblende, is very fusible. To pass over the obviously more modern ruins at this place,[3] as not concerning the present question, there are at a certain stage down the hill the well-marked traces of a work which once seems to have encircled the whole. It is a kind of fortification well known to antiquaries as occurring frequently in the ancient British hill forts; and it resembles a modern military field work, as it consists of a single ditch and wall, the latter being formed of loose stones not vitrified. I consider this as part of the original defences, because a similar one is found on Noath.

"The materials in the vitrified wall are, as at Dun MacSniochain, partly roasted without adhesion, and partly vitrified, or glazed or scorified, in a similar manner. It is easy to see that the dark granite forms the vitrified and scorified substances; but, not to enter on the more minute details, which rather concern the chemist and mineralogist than the antiquary, but which are very interesting to them, I shall only further remark, that wherever stones not capable of vitrification themselves have undergone this change, it has been produced by the alkali of the wood used in the process; whence the glazed surfaces of many unvitrifiable substances.

"Now I remarked that at Dun MacSniochain the materials of the hill itself were not vitrifiable, but that a very fusible rock was present at a short distance, or scattered in fragments about the plain. The same is true here; and in both cases the forts are not erected out of the materials nearest at hand, which are infusible, but collected with considerable labour from a distance. It is hence evident that the builders of those works were aware of the qualities of these various rocks, and it is equally evident that they chose the fusible in preference to the infusible, although with a considerable increase of labour."

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[1] Macculloch's *Highlands and Western Isles*, vol. i. p. 283.

[2] This is an exaggeration. It is only about 400 feet high at the moat.

[3] This, we presume, refers to the remains of an oblong tower constructed of lime, mortar, stone, and fragments of the earlier vitrified fort, to which the opponents of Dr Macculloch ascribe a more modern date than belongs to the rest of the structure.

The next vitrified fort of consequence is that upon the hill called Noath, or Top of Noth, in Aberdeenshire. It is thus described by the same author:

"This mountain is the highest point of its own ridge, rising to the height of about 1800 feet above the level of the sea, and of 300 above any part of the surrounding ground, with a steep acclivity. The summit is a plain; and, as at Dunadeer, that plain seems to have regulated the size of the fort, as it occupies the whole space; an arrangement which is equally found at Dun MacSniochain. Nothing can more clearly prove the military and common design of all these works, since they vary in form and size according to the ground they stand on, and are so contrived, just as a military work would be in the hands of a modern engineer, that they may command all the points of access, and prevent the enemy from advancing any where under cover. . . . The area on Noath is nearly twice as large as that on Dunadeer, yet the same system is followed; and in Dun MacSniochain, as I already showed, though the mode of occupying the ground is different, the principle of a complete command is equally kept in view; while other variations are made for the purpose of conforming to the peculiar shape of the hill."

"The enclosure on Noath is a long parallelogram of about ninety by thirty-two yards, slightly rounded at the angles; and it contains a well. Hence also we may conclude that this was a station and a garrison. An entire deficiency of the wall at the eastern side seems to indicate the entrance or gateway; a notion confirmed by its being continuous with a spacious causeway that extends a considerable way down the hill. That connexion also leads us to conclude that this causeway was not a posterior work, but that it originally belonged to the fort. It is made of laid stones, of considerable bulk, with great care and strength, resembling a Roman road; and it is remarkable that a similar causeway leads to the fort of loose stones on the top of Ben-na-chie.

"At Noath, too, as at Dunadeer, there is a similar field-trench and wall, or outwork, on the declivity of the hill; and, though much obscured, it seems also to have formerly surrounded the whole. In both cases it seems to have been intended as a covered-way, to retard the attack on the body of the place. The vitrified enclosure is far more perfect here than in any of these works in Scotland; and it is infinitely more remarkable, since, being unencumbered with soil and vegetation, scarcely even bearing a lichen, we see at a glance the whole effect of its blackness, its bulk, its regularity, and its extent. We may indeed wonder how any one could have imagined such a work the produce of a volcano, and not less how any one capable in the least degree of observation or reasoning could have conceived it the effect of beacon-fires.

"The parts of the wall which have been most perfectly vitrified are, as might have been expected, the most entire: where highest, they measure eight feet from the ground, and the accumulation of soil at the base would justify the addition of two or perhaps three feet more in some places. That rubbish prevents the breadth from being correctly estimated, but this seems, as at Dunadeer, to have been eighteen or twenty feet. And if from that rubbish we may form an estimate of the total height of the wall before dilapidation, and before the growth of soil below, it may probably be taken at twelve feet. I must also remark, that the fallen rubbish, where the standing and vitrified part is eight feet high, consists of unvitrified stones; so that here, as at Dun MacSniochain, and in other examples, the wall, after having been vitrified to a certain height, seems to have been raised by some courses of dry masonry to its total altitude." The state of the various materials which have been here exposed to the fire is so similar to that of those belonging to Dun MacSniochain and Dunadeer, that it is unnecessary to repeat the description.

On the hill of Knockfarril, which lies to the south of the valley of Strathpeffer, two miles west from Dingwall in Ross-shire, there is a vitrified fort. It is a remarkable one, both on account of its size, and because it was one of those which arrested the attention of Mr Williams, the discoverer of these structures. The hill of Knockfarril forms part of a double ridge which bounds the valley of Strathpeffer on the south, and separates it from the valley of the river Conan. The sides of the hill are steep, but at the eastern and western extremities the ascent is comparatively easy. The area upon the top is about a hundred and thirty-five yards in length by about forty-five yards in medium breadth, and is a good deal inclined towards the west. Round the area, and close to the edge of the hill, are found masses of stones cemented together by melted matter, and irregular both in position and in size. The vitrification is superficial, extending only a short way amongst the stones. According to Mr Cardonnel, one of the earliest inspectors of this place, "the enclosure is a hundred and twenty feet long and forty broad within the walls, strengthened on the outside with works at each end. A range of habitations seems to have been erected against, or under the shade of, the outward wall, of which those on the south side seem to have been higher and larger than those on the north. There are two wells in the middle, which, on being cleared out, filled with water. On the skirts of the hill to the south are many detached buildings, which, from the stratum of dung found on removing the ruins, appear plainly to have been used for securing the cattle. This place seems to have been anciently of consequence, and the residence of some powerful chief, from a road which leads through the hills to the north-west sea. To the east of the works are a number of vitrified ruins, extending for a considerable way along the ridge of the hill. The end next the fort seems to have joined the outer wall, and consisted either of two parallel walls, closed above, with a passage between them under cover, or a high wall broad enough to walk on. In this wall there is the vestige of a break about the middle, over which a bridge has been laid, to be drawn up or removed as occasion might require."

Mr Williams caused several cuts to be made across the area in different places, in which, Sir George Mackenzie[1] observes, a considerable quantity of rubbish is to be seen. "This rubbish," says he, "appears to have been collected for the purpose of extending or forming the area on the top; and it would seem that much labour had been bestowed in accomplishing in this manner what might apparently have been effected more easily by cutting down part of the summit." The vitrified masses appear in many instances to have been displaced; and it seems pretty evident that the rampart was originally constructed with as much regularity as the nature of the materials would admit, both in order to render it more durable, and also to make it serve the purposes of defence.

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[1] Article Forts, Vitrified, in Edinburgh Encyclopædia.

The fort next in importance to that of Knockfarril is situated upon the hill of Craig-Phaidrick, near Inverness, "which," according to Cardonnel, "has this peculiar circumstance, that there appears to have been two vitrified walls quite round the area. The inner one seems to have been very high and strong, the outer wall but low; probably the space between was intended for securing their cattle, as there are no remains of dry-stone buildings, such as are found near the rest. Several parts of this outer wall appear quite entire, sticking to the firm bare rock, where it was first run. The area within the inner wall is near eighty paces long and twenty-seven broad." Of this fort we have an account by Mr Tytler, afterwards Lord Woodhouselee. The hill itself is a small conical eminence, forming the eastern extremity of that ridge of mountains which bounds Loch Ness on the north-west side. It is situated about a mile to the north of Inverness, and is accessible on two different quarters, namely, the west and south-east; the former affording entrance by a narrow level ridge joining the hills on Loch Ness, and the latter by an easy ascent from the high ground above Inverness. On approaching the hill from the west, the traveller first meets with a road cut through the rock from the bottom to the top, in most places ten feet broad and nearly as many deep, winding, for about seventy feet, in an easy serpentine direction, by which he gains an ascent over a steep rock otherwise quite inaccessible from that quarter. In ascending by this road there appears, towards the middle, on the right hand, a small platform overhanging the passage, and inclining by a very gentle declivity to the very edge of the rock. Four enormous stones, which are placed upon the platform, and on the edge and extremity of it, have evidently been guided by art into that position, it being impossible that they could have rested there had they been rolled down from the higher parts. The obvious reason for placing them in such a position has been, that on an alarm of danger they might be projected into the path below, which could be effected by the efforts of a very few men; and when done, the passage would be entirely obstructed, or at least rendered so difficult that it could be defended by a few men against any number of assailants. Some other large stones are placed on an eminence to the left, probably with a view to block up a hollow channel, by which an enemy might have attempted to ascend. When the traveller reaches the top of the hill, a few feet below the rampart which crowns the whole, there appears an outward wall, approaching on the sides of the hill so near the upper rampart as to have only a trench of ten or twelve feet wide between them. This outward wall is in some places so low as to be almost level with the rock, though in other places it rises to the height of two or three feet; but even where lowest, it may be traced by a line of vitrified matter sticking fast to the rock all along, and nearly of the same breadth, which is about nine feet. The remains of this wall are strongly vitrified, excepting in one place on the north side, where, for about seventy yards, the rampart is formed only of dry stones and earth. At the east side, where the hill is more accessible, there is a prodigious mound of vitrified matter above forty feet in thickness. At the south-east corner, and adjoining to this immense mound, is an outwork, consisting of two semicircular vitrified walls, with a narrow pass, which appears to have been the principal entry to the fort, cut through in the middle.

The inner wall, surrounding the summit of the hill, encloses an oblong level area of about seventy-five yards long and thirty broad, rounded at each of the ends like the outward wall. It is of considerable height, and nearly of the same thickness with the outward one. It has some appearance of having been defended with four turrets or bastions; but the traces are so imperfect that Mr Tytler does not lay much stress on his observations in this respect; a number of small tumuli of earth, with a stone in the centre, were more discernible. On the east side a portion of the internal space appears separated from the rest by two ranges of stones fixed strongly in the earth, and forming a rectangular parallelogram. "This separation," says our author, "is immediately discernible by the eye, from this circumstance, that the whole of the enclosed summit has been most carefully cleared from stones, of which there is not one to be seen, unless those that form this division, and the single one in the middle of the circle of tumuli above mentioned. What has been the design of this separated space it is difficult to conjecture. It might perhaps have marked the residence of those of a higher rank, or served as a temple for the purposes of devotion." At the east end of the large area on the summit is a well of about six feet in diameter, which has probably been sunk very deep in the rock, though now it is filled up with rubbish to within a yard of the top.

In the parish of Meigle, in the county of Perth, there is a hill called Barryhill, which seems to have been fortified with particular care. "Its summit," says Dr Playfair, by whom it has been described, "was levelled into an area a hundred and eighty feet long and seventy-two broad. Around the area a mound of earth was raised from six to eight feet high and ten to twelve broad at top. On this mound a wall of freestone was built, without any cement whatever. The foundation of the wall was composed of rough granite, and still remains. It is of the same breadth with the summit of the mound, but the height of the wall cannot be known. Gordon's estimate of it is very erroneous. Among the ruins there are several pieces of vitrified stone, but these vitrifications must have been accidental, as they are few and inconsiderable. Along the west and north borders of the area are barracks, or huts of dry stone, and sufficiently sheltered by the mound and wall; but no structures of this sort can be traced in the south part of the area. As the north and west sides of the hill are steep, and of difficult access, there was no need of an outer ditch in these quarters; but towards the south and east, where the hill gently slopes, there is a ditch ten feet broad and twelve to sixteen feet below the foundation of the wall. At the south-east extremity of the fort a narrow bridge was raised over the ditch, eighteen feet long and two broad, except towards each end, where the breadth was increased. It was composed of stones, laid together without much art, and vitrified above, below, and on both sides, so that the whole mass was firmly cemented. That an opening was left below, after the process was finished, is doubtful. On the upper part of the bridge a stratum of gravel was laid, to render the passage smooth and easy. This is the only part of the fort intentionally vitrified. A few yards distant from the ditch there is an outer wall, the foundation of which is about eight feet lower than the summit of the mound. The approach to the fort is from the north-east, along the verge of a precipice; and the entrance was secured by a bulwark of stone, the ruins of which are extant. There is no vestige of a well within the fort; but westward, between the basis of the mound and the precipice, there was a deep pond or lake, recently filled up by the tenants in that neighbourhood. About a quarter of a mile eastward, on the declivity of the hill, there are some remains of another oval fort, of less extent than the preceding, consisting of a strong wall and ditch. Tradition says that there was a subterraneous communication between these forts, which is not improbable."

In reference to this description of Dr Playfair, Sir George Mackenzie observes,[1] "On going to examine what Dr Playfair has called a bridge, I found that this considerable mass consisted of primitive rock stones vitrified. It had not the slightest resemblance to a bridge, either in its form or apparent use." He goes on to state that its position is in the bottom of the trench, between the summit and the outer rampart; and then observes,[2] "The singularity of Barry Hill is in the vitrified matter being in the trench. If it shall afterwards be found that the whole extent is composed of melted stones, this circumstance also will be remarkable, as it will indicate an intended collection of vitrifiable stones. But if detached vitrified masses only shall be found, then their presence may be presumed to have been accidental."

Near Creich, in the county of Sutherland, a ridge projects into the Frith of Dornoch, terminating in an abrupt precipitous hill. The ridge runs nearly east and west, and the top is of difficult access; whilst the summit, the outline of which is very irregular, is encircled by a rampart of loose stones. Within this there is another rampart of the same kind, which encloses the remains of a building constructed of stone and mortar. It is about thirty feet square, the walls being three feet thick, but not now more than four feet in height. There is a spring of water on the outside of the rampart, and at a short distance within it there is a well, which has been filled up. What renders this ruin remarkable is, that within the enclosure of the rampart, and at one end of it, there runs across the whole summit a mass of stones displaying abundantly the marks of fire; and the vitrification, according to Sir G. Mackenzie, is entirely confined to this part of the hill. The surface of the hill within this rampart is uneven and rocky; and that part of it which is crossed by the vitrified mass is rather lower than the eastern portion.

Near the church of Amwoth, in the county of Kirkcudbright, there is a steep rocky hill about three hundred feet high, the summit of which has been fortified. "The top, which forms a level area thirty paces long and twenty broad," says the Rev. Mr Gordon, by whom it has been described, "is nearly surrounded with an irregular ridge of loose stones, intermixed with vast quantities of vitrified matter. The stones, consisting of the common blue schistus of the country, have been softened, twisted, and partly fused by the fire. These heaps of loose stones and vitrified matter are scattered irregularly over the top of the fort, and exhibit no appearance of having ever formed a continued wall. The vitrification is only partial and superficial, and seems to have been the accidental effect of large fires kindled on these high rocks, either for some domestic purpose, or for signals to alarm the country on the approach of an enemy. It was formerly believed that these vitrified forts were peculiar to that part of the island which is north of the Forth. But besides the one described above, there are two others in the country, and they all command a very extensive prospect of the sea."

In the island of Bute, in the parish of Kingarth, there is a vitrified fort; and in Cantyre, at the entrance of the bay of Carradale, on a small island, about a rood of ground is enclosed by vitrified masses. Others have been observed in Argyleshire, particularly one on the hill of Dunskeig, which commands the entrance of Loch Tarbert. On the same hill, ramparts have been constructed with dry stones, without any vitrification.

On the hill of Laws, which is situated near the village of Sturdymuir, a few miles north-east from Dundee, there is a vitrified fort. The area on the summit is 133 yards in length and 66 in breadth, and all round it are to be seen the vestiges of a broad rampart, and large masses of vitrified stones. About four miles east from Forfar is the castle-hill of Finhaven, the vitrifications on which have been compared by Dr Anderson to the effects of fire in a lime-kiln. The enclosed area is about 140 yards long and upwards of forty broad, and the walls in some parts of this fort have been laid bare, so as to appear at least ten feet high. There is no perfect description of the extent of the vitrification, but Mr Tytler says that marks of it are visible all round the summit. Dr Anderson describes it as appearing here and there in horizontal or nearly horizontal streaks. Dr Jamieson informs us that the stones are in courses, and banded together, and that they have been very unequally and irregularly affected by the fire, and many of them not at all. Seven or eight varieties of stone appear to have been employed. On this hill there are several cross walls, and the vestiges of outworks, which altogether present much that is interesting to the curious in such subjects.

It is impossible in this place to describe all the vitrified ruins, amounting to about fifty, and extending over Perthshire, Forfarshire, Kincardineshire, Aberdeenshire, Banffshire, Morayshire, Inverness-shire, which contains an immense number, Ross-shire, Cromartyshire, Argyleshire, Buteshire, Berwickshire, and Galloway. Dr Hibbert, who has laboured with great industry in attempting to solve the problem of their probable origin, in a paper which was read to the Society of Antiquaries of Scotland in 1831, informs us that he had discovered masses of vitrified matter at Elsness, in the island of Sanday, one of the Orkneys. Of these curious remains, which he calls vitrified cairns, or beacon cairns, he counted more than twenty. They are of a round shape, from three to five yards in diameter, and elevated from two to three feet above the surface of the ground. The stony fragments of which they are composed appear to have been collected from the beach, and consist of what geologists call an argillaceous schist. Their fusibility they derive chiefly from the feldspar, or rather the alkali, which they contain.

At Jedburgh, and we believe in other parts of Scotland besides those above mentioned, vitrified matter has been found, but only in small quantity, and not presenting any appearance of having formed part of a building.

Not long after these structures were discovered by Mr Williams, the notion that their vitrification was of volcanic origin was started, and soon became very prevalent. It was embraced by Mr Pennant, the eminent naturalist, who came to this conclusion after an examination of Craig-Phaidrick. A similar view was adopted by other individuals; and the appearance of the hill in question, as well as that of some others of these forts, is not ill calculated to favour this opinion. But as other ruins of the same kind came to be discovered, and an appearance of regular construction began to develop itself, another and a more rational hypothesis was advanced. In the year 1777, Mr Williams published a pamphlet, in which the validity of the volcanic theory was opposed. This author first assured himself, on the authority of Dr Black, the celebrated chemist, that many varieties of the rocks of Scotland were fusible by artificial means, and then advanced the theory that vitrification was artificially induced, as a cement for the consolidation of ramparts of loose stones. He supposed that they were constructed in the following manner: Two parallel dikes of earth or sod being raised in the direction of the intended wall, with a space between them sufficient for its thickness, the fuel was put in and set on fire. The stone best adapted for this purpose, called the *plum-pudding stone*, is everywhere to be found in the neighbourhood. Stones of this description were laid on the fuel, and, when melted, were kept by the frame of earth from running off; and by repeating the operation, the wall was raised to a sufficient height. Amongst others who adopted the theory of Mr Williams, was Dr Anderson, who improved upon it by suggesting that a peculiar kind of vitrifiable ore was employed to promote the vitrification.

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[1] *Archæologia Scotica*, vol. iv. p. 184.

[2] *Archæologia Scotica*, ibid.

In a paper published in the year 1827, in the Transactions of the Royal Society of Edinburgh, another hypothesis was advanced by Lord Woodhouselee, who had some time before made an extensive survey of the vitrified forts. Mr Williams, probably from too partial an examination, had erroneously asserted that every stone composing a vitrified fort had been acted upon by the fire; but Lord Woodhouselee finding that the fact was not so, and that many parts of the walls showed no marks of vitrification, began to doubt the theory of Mr Williams. Whilst he agreed with him in thinking these structures artificial works, he differed from him in supposing that their vitrification was accidental. It was not, he said, in their construction, but in their demolition, that they were vitrified; and this may be supposed to have occurred from many circumstances. In the rude state in which Scotland existed at the early period to which the erection of these forts must be attributed, it is probable that their buildings, both for habitation and defence, would be frequently constructed of loose stones of an irregular shape, which, of themselves, could scarcely form a wall of any tolerable strength. Hence it became necessary to employ wood as well as stone in their construction. This kind of building, then, in our author's opinion, was begun by raising a double row of palisades or strong stakes in the form of the intended structure, in the same way as in that ancient mode of building described by Palladio under the name of *riempiuta a caffa*, or coffer-work. These stakes were probably warped across by boughs of trees laid very closely together, so as to form two fences running parallel to each other at the distance of some feet, and so close as to confine all the materials, of whatever size, that were thrown in between them. Into this intermediate space, his lordship supposes, were thrown boughs of trees, earth and stones of all sizes, large or small as they could quarry or collect them. Very little care would be necessary in the disposition of these materials, as the outward fence would keep the mound in form. In this way it is easy to conceive that a very strong bulwark might be reared with great dispatch; which, joined to the natural advantage of a very inaccessible situation, and that improved by artful contrivances for increasing the difficulty of access, would form a structure capable of answering every purpose of security or defence. The most formidable attack against such a building would be fire, which would no doubt be always attempted, and often with success, by an enemy who undertook the siege. If the besiegers prevailed in gaining an approach to the ramparts, and, surrounding the external wall, set fire to it in several places, the conflagration must speedily have become universal, and the effect may be easily imagined. If there happened to be any wind at the time to increase the heat, the stony parts could not fail to come into fusion; and as the wood burnt away, sinking by their own weight into a solid mass, there would remain a wreck of vitrified matter tracking the spot where the ancient rampart had stood; irregular, and of unequal height, from the fortuitous and unequal distribution of the stony materials of which it had been composed.

The fifth and last theory is, that the vitrification of these forts was the result of beacon-fires. This opinion first obtained supporters amongst the contributors to Sir John Sinclair's *Statistical Account of Scotland.* It was afterwards advocated by Sir George Mackenzie in the article previously referred to; and latterly by Dr Hibbert, who has published several ingenious papers on the subject in the *Archæologia Scotica.* Such are the various hypotheses which have been advanced explanatory of the singular phenomena of vitrified forts. To present any thing like a complete view of the arguments which have been produced in support of each, would occupy more space than can here be allotted to the subject; an abstract, therefore, of those which are most striking can only be given. In general those who have considered the subject at all are divided into two classes; namely, those who support the theory of Mr Williams, and those who advocate the beacon-fire theory. Amongst the most eminent of the former class is Dr Macculloch, who published a memoir upon the subject in the Transactions of the Geological Society of London, and also treated of it in his work on the Highlands and Western Isles of Scotland.

But, first, with respect to the beacon theory. That at a very early period of Scottish history mountain fires were lighted for the purpose of alarming the country when an enemy appeared upon the coast, is an undoubted historical fact. The primary assumption is therefore undeniable. With respect to their origin, many of those who support the hypothesis that the vitrification of these forts is the result of beacon-fires, have offered conjectures as to the date of their erection. Upon this subject Dr Hibbert observes,[1] "The coasts of Scotland began to be annoyed by the predatory visits of the Vikingr (Sea-kings) about the end of the eighth century; but it was not probably until the Scots had obtained a complete ascendancy over the Picts, by which both were united under one government, that systems of beacons were formed to provide against the sudden descent of the Scandinavians, who invaded them from the Danish or Norwegian shores, or from countries which they subsequently colonized, namely, from Shetland, Orkney, Caithness, Sutherland, the Hebrides, Ireland, or the Isle of Man. The Murray Frith, as we learn from ancient Sagas, was one of the most convenient landing places for the Northmen; and hence we must look to this locality for the greatest proportion of vitrified sites. The number of such as have been traced within sight of each other, in a direction east to west from Banff to Dingwall, and in a direction north to south from Cromarty to Fort Augustus, may be estimated at twenty; but it is probable that their actual amount will be eventually found to be much more. Two vitrified eminences appear near Huntly, connected apparently with the line of coast extending from Kinnaird's Head to the mouth of the Dee. More south, a chain of vitrified sites, nine or ten in number, appears to have conveyed signals from the line of coast which stretches from Kincardine to the Tay, being prolonged from Stonehaven or Dundee to the neighbourhood of Dunkeld or Crieff. On the west coast, again, we find similar vitrified sites at Bute, Cantire, Isla, Loch Etive, Loch Sunart, Fort William, or at Arisaig. The number which subsists on the west yet remains to be ascertained; about twelve have been enumerated. Lastly, at Galloway, three occur, apparently as signals against the marauding colonists of Ireland.

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[1] *Archæologia Scotica*, vol. iv. p. 170.

"But it must be kept in view, that it is highly improbable that the original intent of the whole of these vitrified sites was that of affording convenient localities for beacon-fires. There is no necessity whatever, *cœteris paribus*, that signal lights, merely giving notice of the approach of an enemy from the sea, should be situated on fortified stations. It is not improbable, therefore, that the rude ramparts themselves might, at a still more remote period, have been erected by the oldest inhabitants of Albyn, namely, by the Caledonians and Picts; and hence their occasional or very partial vitrification would merely indicate the later use to which the eminences upon which they were situated had been applied, when the Scots, who succeeded to far earlier inhabitants, were called upon to repel new invaders from the sea."

Dr Hibbert goes on to remark, that after the Norsemen had acquired a permanent settlement in Scotland, and also in other places, they themselves became liable to sudden piratical descents from their own countrymen; to guard against which they instituted, in every country where their arms prevailed, still more perfect systems of beacon-fires, the wardenship of which was enforced by the most rigorous laws. This we are informed of by ancient Sagas, and edicts on the subject are found in many early codes of the north of Europe. From two ancient writers, Olaus Magnus and Snorro, passages are quoted, which go to prove that large trees were felled, formed into piles upon mountain tops, and then set fire to, for the purpose of giving intelligence to the country of a hostile invasion. These, however, obviously apply to countries upon the Norwegian coast in particular; but they may be extended to those portions of Scotland which were under the domination of the Norsemen.

The same writer further observes, that vitrification may in some cases have resulted from fires having been lighted in these forts during the observance of religious and other festivals. The custom of kindling immense fires on occasions of feasting was certainly common in ancient times; indeed, the custom of the Baaltein, or festival in honour of Baal, is observed in some districts even at the present time. He also supposes that many of the sites where vitrified remains occur were places of rendezvous for tribes or clans, upon public occasions of peace or warfare; and also that the ramparts afforded a shelter for cattle as well as for human inhabitants. Dr Hibbert sums up his evidence in support of the beacon theory by giving a list of the ancient forests of Scotland, from which it appears that the country was formerly in a densely wooded state, and hence afforded ample materials for kindling beacon-fires upon the grandest scale, and celebrating the rites of Baal, or any other object of worship, in a manner sufficiently flagrant to propitiate the favour of the most exorbitant fire-loving god of antiquity.

In the Transactions of the Society of Antiquaries of Scotland, vol. iv. are various papers relative to vitrified sites, which were read to the society by Dr Hibbert in the year 1831. These contain several communications from Sir George Mackenzie, Mr George Anderson, and others, in which the main principle, that these forts were beacon stations, is supported by an attempt to establish the fact that the hills on which they are found form a regular chain of signal stations which command each other. By this arrangement a fire kindled on one of them could be seen by those contiguous, and thus intelligence communicated throughout the whole line, on whatever part of the coast the enemy might make their appearance. This hypothesis was advanced by Sir George Mackenzie, in his article on vitrified forts in the Edinburgh Encyclopædia, where he also lays much stress upon the appearances exhibited by the hill of Dun Creich, in which, as formerly mentioned, only the singular wall which runs from one side to the other of the rampart shows marks of vitrification. The reason assigned for traces of fire being only partially visible in this and in all the other forts is, that the combustible matter was always placed so as to be sheltered from the wind. "To be satisfied," he observes, "whether the signal-fires should be kindled on or beside a heap of stones, we have only to imagine a gale of wind to have arisen when a fire was kindled on the bare ground. The fuel would be blown about and dispersed, to the great annoyance of those who attended. The plan for obviating the inconvenience thus occasioned, which would occur most naturally and readily, would be to raise a heap of stones on either side, of which the fuel might be placed to windward."

Such are the leading arguments produced in support of their doctrine by the advocates of the beacon theory. The most distinguished advocate of Mr Williams' views is Dr Macculloch, to whose works on the Highlands and Western Isles we have already referred. The doctor observes, with reference to the partial vitrification of the walls, that had the walls been the enclosures of beacon-fires, every stone from the summit to the base must have felt their effects alike. But the great variety found in the forms and sizes of these works, their obviously military and defensible character, and the enormous size of some of them, as for instance that at Noath, seems, in his opinion, to render the notion of their having been signal-stations scarcely worth refuting. "At Amwoth, in Galloway," he says, "the hill has been scarped by art, so as to form a deep ditch close to the foot of the wall. Nothing of this kind could have been required for a beacon; and it is further remarkable, that the transverse wall at Dun MacSniochain is a common expedient for defence in the ancient British works that occupy peninsulas or promontories; as at Castle Trereen, Zenor, and Tintagel, in Cornwall. The advanced covered-ways of Noath and Dunadeer, and the causeway of the former, would be equally unnecessary on such a supposition; nor, at Noath, could any possible purpose of a beacon have demanded or justified such an enormous work, whether we consider the area enclosed, or the height and thickness of the walls.

"To imagine an area of 2700 square yards covered with burning wood, and to conceive a wall that would have required the labour of many hundred men for weeks, built for no other purpose than to enclose what did not want enclosing, are dreams not deserving a serious examination. If a chemical argument were wanted in addition to these, it would be found in the fact, that though all this wood, a forest in itself, were collected and lighted, when a square yard would have served the purpose as well as two or three thousand, it would not vitrify its enclosure in the manner in which these walls are vitrified; as the current of air from without would, by cooling the external part, impede its action on the outside, where the fusion is as complete as within. It has been asserted that these vitrified forts actually did communicate in chains, or in connection, throughout the country. Nothing but a similar ignorance respecting these works and their places could have led to such an assertion; it is not the fact; in many instances it is physically, geographically, and optically impossible; and the mere supposition involves equal ignorance of the political state of Scotland in ancient times, or else hypothesis respecting its union under one organized government, which is purely gratuitous. Many of them indeed are placed in situations so low, or so entangled among hills, as to preclude all communication of this nature; as is the case in Isla, in Morven, in Ardnamurchan, in Galloway, and apparently along the course of the Bogie in Aberdeenshire."

Dr Macculloch goes on to observe, that the appearances of the burned and vitrified substances appeared to him to prove that a long-continued and intense heat had been applied, neither of which effects could have resulted from the burning down of a wall formed of stone and wood, as Lord Woodhouselee supposed was the case. The plan of constructing a species of furnace by means of earthen mounds, into which stones and fire were introduced till the structure was finished, not only, according to our author, answers all the conditions, and, among the rest, that of vitrifying the materials below more perfectly than the upper ones, but is confirmed as to its probability and efficacy by a practice in use in some parts of India. We are informed by a French engineer, that in that part of Asia houses of clay are burned into a solid brick, in this very manner and at this day, in order to prevent the effects of inundations. Dr Macculloch further observes, that the art seems to have been practised in England, though with a different end in view. Some years ago a house was demolished in Shropshire, part of which, of unknown antiquity, was covered with an entire crust of glass, apparently for the purpose of protecting it from the effects of the weather.

With respect to the antiquity of these forts, little can be advanced that is satisfactory. Our author offers a speculation, that if they were built by one people, in the widely-separated districts where they are found, they ought to belong to a time prior to the division of Scotland into a Pictish or Caledonian, and a Scottish or a Celtic and Norwegian dominion. Thus they should be referred to the aboriginal Celts, or first settlers of Scotland; that people whom the Pictish invaders found, and on whose defeat they settled themselves in the conquered country. The same writer concludes his observations by expressing a hope "that some future traveller in the East will find further reasons to prove that they are among the earliest military works of our oriental Celtic ancestors."

Such are the arguments brought forward by each of the parties in support of their theories as to the origin and design of vitrified forts. It must be confessed that a case perfectly satisfactory and free from doubt is made out by neither of them, although the balance of probability seems in favour of the opinion that they were regular military works, vitrified on purpose, for the sake of strengthening the walls at the time when cement was unknown. In support of this view of the case, we shall offer a few remarks.

The main question is, were these forts intentionally vitrified, for the purpose of cementing the walls together? or was the vitrification an accidental result of beacon-fires being lighted up within their enclosures? It would certainly be injudicious to advocate either theory exclusively. For if, on the one hand, we maintain that they were intended for places of strength, some of them are evidently too small, and would have been utterly useless for that purpose; and if, on the other hand, it be asserted that they were signal-stations accidentally vitrified by signal-fires being lighted there, then the size and elaborate construction of some of them indicate their adaptation to something of far more importance. Sir George Mackenzie observes: "We allow, that while these hills were chosen for signal-stations, they were also used as places of defence. And indeed it would have been strange if posts of so much importance had been left without the means of resistance. All have agreed that they were places of more or less strength, though perhaps such lofty and exposed situations were not well chosen for protracted warfare. Had they been merely places of retreat, an invading enemy would certainly overlook them, as he could overrun and pillage the country without the possibility of his being annoyed from them; or if there was any risk of his progress being interrupted, the situation of the hills would render it easy for a small party to coop up the garrison. But as an enemy would always endeavour to approach unseen, and to prevent the country from being alarmed, these stations would undoubtedly be objects of attack; and hence we should be warranted in supposing that they were to a certain extent fortified, even were the appearance of ramparts less unequivocal." Now, as Sir George advocates the opinion that vitrification was an accidental result of fires being kindled in these forts, of what possible use could they be as strongholds? For if these watch-towers were lit when the enemy appeared, then of course those within would be compelled to evacuate them, as no living thing could have breathed within some hundred feet of the place where such immense conflagrations took place. It seems, therefore, a very improbable circumstance, that men, even allowing that they were sunk in the lowest barbarism, would laboriously construct and fortify a place which they must have been aware it would be necessary to abandon at the very time when they were most needed.

With regard to the vitrification on the hill called the Top of Noth, the same writer observes: "The vitrification is only in the inside, which is a very satisfactory confirmation of the idea that it has been produced by signal-fires. Had the outside of the rampart on Top of Noth[1] been vitrified, we might have been warranted in concluding that fire had been used to strengthen it. Had the inside been vitrified with this view, it is impossible to conceive that no attempt was made to cement the outside also; since in every structure for defence, however rude, we find the strongest, and not, as in this instance, the weakest, part opposed to the approach of an enemy." This reasoning seems by no means conclusive. Vitrification was had recourse to, not because the vitrified matter thus formed was of a stronger nature than the materials which it bound together, but simply because it did bind or cement them, so as to form one solid fabric. Now this might be accomplished either on the one side or the other, without making any very great difference as to strength. It is, however, very problematical if those who constructed these fabrics had any thing of this kind in view when they erected them; and as vitrification occurs on the outside of other forts, little weight can be attached to this argument. In those forts which were vitrified only on the inside, it seems probable, that from the nature of the hill where they stood, it was found impracticable to accomplish it on the outside. Various other circumstances besides the nature of the ground may have occurred to determine both the extent of the vitrification and the choice of the parts where it was to be effected.

Sir George Mackenzie further observes, with respect to the situation of the forts: "We do not remember an instance in which there is not much higher ground immediately contiguous to the hills on which the vitrifications are found."[2] Now, granting that the situation of every one of them was a commanding one, and that the whole were connected together like links in a chain, so that a fire on any given hill could readily communicate intelligence to the others, is it not probable that those who

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[1] Other individuals, who have examined the above fort, inform us that it is vitrified on the outside as much as on the inside.

[2] There is no high ground contiguous to Dunadeer or to Noth.

erected the signal-stations would have chosen the highest accessible elevations, such as towered above all the neighbouring heights, and commanded the widest range of country? By this means the end would not only have been more perfectly effected, but the number of signal-stations would have been lessened by one half, or perhaps more; and to suppose that the aboriginal inhabitants of Scotland would have overlooked this obvious fact, is to attribute to them a degree of ignorance below that of the most savage tribes which the enterprise of modern times has discovered. An erroneous notion seems to prevail as to the extent of fire requisite to convey intelligence of the approach of a foe. But it was not necessary to keep up the combustion for any length of time. Supposing that these were signal-stations, a temporary blaze would communicate all the intelligence that was required, and just as much as could have been conveyed, although the fire had been continued for a considerable period of time. The more that the advocates of the beacon theory insist on their being a regular chain of forts, the less necessity there is for supposing that the fires were so large, and continued for such a length of time, as to vitrify rocks. If it be urged, as it has been, that vitrification was produced, not by the intensity of the fire at one time, but resulted from repeated applications of it, still this could only apply to vitrification upon the surface; for, allowing that on any given occasion, when the beacon was lighted, the heat was sufficient to vitrify the rocks one inch inwards, upon the next occasion when it became necessary to repeat the signal in the same place, it is not to be supposed that it would vitrify it another inch farther inwards. This supposition would involve the absurdity that the fires lighted were on every successive occasion stronger and stronger, a circumstance which was not likely to occur. Besides, considering the height to which it was necessary to convey the combustibles, it is probable that, when the fires were once found to answer the purpose, and the people knew that they would do so again, they would become less rather than greater. Hence we may conclude, that in every case where the vitrification penetrates to some depth inwards, it resulted from an intense *continuous* heat, kept up for a long period, not from a series of petty fires. Where *the chain of communication was regular*, there was, as we have said, no necessity for such stupendous piles of burning wood as were requisite for vitrifying some feet of a wall; the combustion of a few trees would have accomplished the end as well as if the blaze of Ætna had irradiated the summits of the hills. But though not an absolute necessity, there was a degree of propriety which could scarcely have been overlooked in placing them within sight of each other, as has been asserted by the advocates of the beacon theory. Dr Macculloch, however, as we have seen, has denied that this is the case; but his statement must be taken with caution, for a great many sites probably remain undiscovered. However, the main question will not be affected by the decision of this point. The more numerous the forts were, the less use was there for immense conflagrations, and hence the probability is lessened that they were so extensive as to fuse masses of rock.

The following is a quotation from one of the papers of Dr Hibbert: "None of these vitrified forts exhibit, as from many writers we should be erroneously led to suppose, any regular masonry in their structure. Unhewn fragments of stones, and water-worn boulders, sometimes mingled with smaller gravel, appear in a quantity almost exceeding belief, following the contour of the summit of a mountain, or, as in the instance of a fort which is situated in the Kyles of Bute, following the contour of a small holm or islet, elevated a few yards only above the level of the sea; and in cases where, owing to the more exposed nature of the ground, a stronger defence is demanded, a double or even treble rampart of the same rude materials is added. The vitrification which characterizes these forts is, in some few of them, displayed to an extent that is perfectly astonishing; while in other instances it is with difficulty to be detected."

At an early period, the want of proper tools for either quarrying stones, or hewing them into symmetrical forms, would compel builders to seize upon such masses as presented themselves, whether round, oval, or of any other shape. Now, in order to form a level bed upon which these might repose with any degree of security, they would naturally have recourse to gravel and debris of some kind, for at this period they seem to have been ignorant of cement. It cannot be denied that a very unstable erection would result from this method of building; for the walls would not only be easily demolished by a hostile force, but rain, which falls in large quantities in mountainous regions, by percolating through the fissures, would soon have washed away the unconsolidated mass. But, granting that signal-fires had accidentally vitrified the walls in one instance, is it not to be presumed that the idea of cementing the walls of their strongholds by means of fire would suggest itself to those who observed the fact? This is an extremely probable circumstance; and it is strongly corroborated by the fact mentioned by Dr Macculloch, and many others who have examined these ruins, that stones of an easily fusible nature were brought from some distance, whilst those composing the mountain upon which they stood were neglected. This was certainly done intentionally; but of what use was it to build of such materials the walls of what may be called a furnace? Obviously of none whatever. On the contrary, there was an evident disadvantage. For as in every fire-place a plentiful supply of air is necessary to support combustion, it is clear, that as soon as the rocks began to melt, the interstices would have been filled up, and the combustion immediately checked. It was the object of the builders to construct their fire-places of unfusible rocks, and it was also necessary to leave numerous openings for the free admission of air; but it would appear that no indication of any such thing is to be traced in these ruins, a circumstance which strongly supports the truth of the hypothesis that they were regular forts, not beacon-stations. The presence of wells or tanks for water in some of these forts, of double and of triple walls and causeways leading up to them in others, besides many other circumstances which might be adduced, all go to prove the same view.

In a word, the probability is, that the natives having observed the effects of fire upon some stones of ramparts which enclosed beacon-fires, acquired the idea of consolidating their places of strength by the same means, at a time when the use of cement was unknown. Those parts of vitrified forts which show that mortar was used in their construction must, according to all accounts, be referred to a later date than that of the vitrified portions of these fabrics. (R. R. R.)

FORT AUGUSTUS, the central fort of three such establishments erected for the purpose of overawing the Highlands since the Revolution. It is situated in the centre of a beautiful plain or opening in the hills, in the heart of Inverness-shire, at the western extremity of Lochness, and on the south bank of the Caledonian Canal. Fort Augustus is the weakest of the three forts mentioned, and was easily taken and destroyed by the Highland insurgents during the revolt of 1745. It resembles a gentleman's house more than a place of military strength; and, though capable of containing 400 soldiers, is now sufficiently garrisoned by a few veteran artillerymen.

FORT GEORGE, a fortress of Scotland, in the county of Inverness. It is an irregular polygon of six bastions, mounted with eighty pieces of cannon, and is situated on the southern extremity of a low peninsula which projects into the Murray Firth, about twelve miles north-east of Inverness. The whole fortress covers an area of ten Scotch acres, and the barracks possess accommodation for about 3000 troops. This fortress was begun in 1746, and completed in 1764, at an expense of L.160,000. It was constructed with the intention of keeping the Highlands in check; but for this purpose it is now no longer required, and only serves as a barrack for soldiers. It is usually occupied by a governor, lieutenant-governor, several inferior officers, and one or two companies of soldiers. The view from the ramparts is extensive and varied.

FORT ST DAVID, a town of Hindustan, on the sea-coast of the Carnatic, situated on the river Tripapolore. Three rivers of considerable size all fall into the sea in the space of four miles within the bounds of Fort St David. The Panaur is about 1800 yards to the north of the Tripapolore, and the two streams communicate by a canal which runs parallel to the margin of the sea, from which it is distant about 1000 yards. Fort St David stands in the angle formed by the junction of the canal with the Tripapolore, which passes close to the site of the fort, and then sends to the south an arm that joins at no great distance the river of Bandapollam, where both in one channel continue along the eastern side of Cuddalore, separated from the sea by a mound of sand. This factory was first established in the year 1691. After the capture of Madras by the French in 1746, the English were besieged here without success; and from this period it continued the head of the English settlements till 1758, when it was taken by Lally, after a short siege, and the fortifications destroyed. It is 100 miles south-south-west from Madras, and 15 south-south-west from Pondicherry. Long. 79. 57. E. Lat. 11. 46. N.

FORT WILLIAM, a fortress of Scotland, in the county of Inverness. It is situated on the east side of Lochiel, and the south side of the small river Nevis, where it falls into that inlet of the sea, at the distance of sixty-one miles south-west of Inverness, and twenty-nine and a half south-west of Fort Augustus. It is of a triangular form, with two bastions mounting fifteen twelve-pounders. The fort was originally built during the usurpation of Cromwell, by General Monk, and occupied much more ground at that time than it does at present. During the reign of William III. it was rebuilt on a smaller scale, and received its name in honour of that monarch. In the year 1745 it stood successfully a siege of five weeks, but is by no means a place of great strength. It is now garrisoned by a governor, fort-major, and a company of soldiers.

FORTALICE, in *Scotch Law*, signified anciently a small place of strength, built for the defence of the country, and which on that account was formerly reckoned *inter regalia*, and did not go along with the lands upon which it was situated without a special grant from the crown. Now, fortalices are carried by a general grant of the lands; and the word has become synonymous with manor-place, messuage, and the like.

FORTAVENTURA, or FUERTEVENTURA, one of the Canary Islands. It is fertile in corn and excellent fruits, and remarkable for its numerous breed of goats and prodigious quantity of goat-milk cheese. For its size and population see the article CANARY ISLANDS.

FORTESCUE, SIR JOHN, an eminent English lawyer in the reign of Henry VI. was descended from an ancient family in Devonshire, though both the time and place of his birth are unknown. He is supposed to have been educated at Oxford, and the great learning displayed in his writings does no discredit to such a supposition; but it is nevertheless altogether uncertain at which university he studied, or whether he ever studied at any. When he turned his views to the legal profession he entered himself of Lincoln's Inn, where he soon distinguished himself by his knowledge of the civil as well as of the common law. In the fourth year of Henry VI. he was appointed one of the governors of Lincoln's Inn, and three years afterwards the same office was again conferred upon him. In 1441 he was made a king's serjeant at law, and the following year chief justice of the King's Bench. As a judge Fortescue is highly commended for his wisdom, gravity, and uprightness; and he seems to have enjoyed great favour with the king, who is said to have given him some substantial proofs of esteem and regard. He held his office during the remainder of the reign of Henry VI. to whom he steadily adhered; and having faithfully served that unfortunate monarch in all his troubles, he was attainted of treason in the first parliament of Edward VI. which assembled at Westminster in November 1461, having been included in the same act by which Henry VI., Margaret of Anjou his queen, Edward their son, and many persons of the first distinction, were likewise attainted. When Henry subsequently fled into Scotland, he is supposed to have appointed Fortescue, who appears to have accompanied him in his flight, chancellor of England; and although the name of the latter is not found recorded in the patent rolls, because, as Selden remarks, "being with Henry VI. driven into Scotland by the fortune of the wars with the house of York, he was made chancellor of England while he was there," yet several writers have mentioned him by this style and title; and in his book *De Laudibus Legum Angliæ*, he calls himself *Cancellarius Angliæ*, which seems to settle the question. Early in 1463, Fortescue embarked at Bamburg with Queen Margaret, Prince Edward her son, and many other persons of distinction who followed the fortunes of the house of Lancaster, and landed at Helvoetsluys, from which the party were conducted by Bruges and Lisle to Lorraine. Being thus expatriated, he remained many years on the Continent, moving about from place to place, as the necessities of the royal exiles required, and endeavouring to promote their interest by every means in his power. But his most important labours during this period were of a different and more lasting kind. Having observed that Prince Edward applied himself wholly to military exercises, and seemed to think of nothing but qualifying himself to command in battle, Fortescue, who had observed in him indications of a sound understanding, judged it high time to endeavour to give him other impressions, and particularly to infuse into his mind just notions of the constitution of his country, as well as a due regard for its laws. With this view he drew up his celebrated work *De Laudibus Legum Angliæ*, which, though it failed of its primary intention, owing to the barbarous murder of the young prince, for whose benefit it was composed, will yet remain a lasting monument of the author's learning and patriotism. When the prospects of the exiles began to brighten a little, the queen and the prince returned to England, accompanied by Fortescue and others, who no doubt hoped that a more auspicious day was about to dawn upon the descendant of time-honoured Lancaster. But destiny still counter-worked the designs of the heroic Margaret. Her attempt to assert the rights of her son totally failed; and the chancellor, forced to reconcile himself as he best could to the victorious Edward IV. wrote an apology for his conduct, which, though Selden had seen it, has never been published. Little further is known respecting the life of this remarkable man, excepting that, amidst all the changes of masters and varieties of fortune, he stedfastly maintained those constitutional principles which he had with equal ability and conciseness explained in the celebrated treatise above referred to. He appears to have died at a very advanced age, though the time of his death, like the date of his birth, has not been ascertained.

Fortescue's masterly vindication of the laws of England, though received with great favour by the learned of the profession to whom it was communicated, did not appear in print until the reign of Henry VIII. when it was published by Whitechurch in 16mo, but without a date. In 1516 it was translated by Mulcaster, and printed by Tottel; and again in 1567, 1573, and 1575, and also by White in 1598, 1599, and 1609. It was likewise printed, with Hengham's *Summa Magna et Parva*, in 1616 and 1660, 12mo; and again with Selden's notes in 1672, in 12mo. In 1737 it appeared in folio; and, in 1775, an English translation, with the original Latin, and Selden's notes, besides a variety of remarks relative to the history, antiquities, and laws of England, was published in 8vo. Waterhouse's *Fortescue Illustratus*, which appeared in 1663, though prolix and defective in style, may be consulted with advantage, and will serve to facilitate the labours of more judicious and able inquirers. 2. Another valuable and learned work by the same author, but written in English, was published in the reign of Queen Anne, under the title of The Difference between an absolute and limited Monarchy, as it more particularly regards the English Constitution, and accompanied with some remarks by John Fortescue Aland of the Inner Temple, London, 1714, in 8vo; and a second edition with amendments appeared in 1719, 8vo. In the Cotton Library there is a manuscript of this work, in the title of which it is said to have been addressed to Henry VI.; but many passages show plainly that it was written in favour of Edward IV. 3. Of the author's other writings, which were pretty numerous, but never printed, we know nothing more than can be collected from the titles, and the commendations bestowed on them by persons who had perused the manuscripts. Those still extant are, 1. *Opusculum de Natura Legis Naturæ, et de ejus censura in successione Regnorum Supremorum*; 2. *Defensio juris Domus Lancastriæ*; 3. Genealogy of the House of Lancaster; 4. Of the Title of the House of York; 5. *Genealogiæ Regum Scotiæ*; 6. A Dialogue between Understanding and Faith; 7. A Prayer Book which savours much of the Times we live in; with some others, which, as the author was a man of great knowledge and observation, will, we trust, yet be printed. When lord-chancellor, Fortescue is said to have drawn up the statute of the 28th Henry VI. on the resumption of certain grants of the crown, which, though much relied on by writers on that subject, is not extant in any edition of the statutes. (A.)

FORTH is the name of the largest river in Scotland. It is first formed of several smaller streams, rising on the north of Ben-Lomond, or flowing from the lakes in the adjacent country. It proceeds easterly in a direct course for above a hundred miles, receiving in its progress the tributary waters of the Goodie, the Teith, and the Allan, above Stirling, and below it the Devon, the Carron, the Avon, the Almond, the Leith, the Esk, the Leven, the Tyne, and others; and it discharges itself into the German Ocean in about 56° 10′ of north latitude. The windings of the river both above and below Stirling are particularly beautiful. The windings above Stirling to Gartmore extend about thirty-three miles in length, though only twenty in a direct line; and towards Alloa the river flows for twenty-four miles in a tortuous course, without advancing more in a straight line than six. Its width at Borrowstownness is four miles, at Queensferry two, at Kinghorn nearly six, between Dysart and Aberlady about twelve, between Elie and Dirleton Common eight, and between St Abb's Head and Fifeness, where the Forth joins the German Ocean, its breadth is from thirty-five to forty miles.

It is so deep as to be navigable by vessels of seventy tons burden as high up as Stirling, and the tide flows a mile above that town. At low water, above Borrowstownness, it seldom exceeds two fathoms in depth; at Queensferry, between Inchgarvey and the north shore, it deepens to thirty-seven fathoms. It becomes shallower again where it widens, till it reaches the north channel between Kinghorn-ness and Inchkeith, where it deepens to twenty-six fathoms. Between Elie and the south shore its depth is sometimes thirty fathoms; and it never exceeds this depth to the westward of its junction with the German Ocean.

The Forth, like other streams connected with the ocean, ebbs and flows twice in twenty-four hours; but the flood and ebb run about two hours longer in the middle than at the shore. It was high water, full and change, according to Captain Thomas, in 1815, at

	H.	M.		Spring Tides, Rise.	Neap Tides, Rise.
Ely Harbour,............	2	11	P. M.	14 feet.	6 feet.
Leith and Burntisland,	2	15		16½	7
At Hopetoun House....	2	30		17	6½

The tides at Leith and Kinghorn rise sometimes as high as nineteen feet above low-water mark, the average being seventeen and a half feet.

There are in the Forth, as elsewhere in similar rivers and arms of the sea, particular currents. Amongst the most remarkable are those known by the name of *leakies*, above Queensferry, and which are particularly observed from Culross to Alloa. These consist in an intermission of the tide at certain places, during the flood at others, and before high water at certain places, the sea ebbing at others; and also whilst the sea ebbs at certain places, and before low water, the ebb intermitting at others, and a flow commencing and continuing some time, after which the ebbing is resumed until low water. This is observable during two hours, and the irregularity occupies more of the river, according as it is spring or neap tides.

Certain winds, acting upon the great mass of the Atlantic Ocean, affect the times at which it is high or low water in the Forth, while their effect upon the extent of the rise or fall of its waters is frequently very considerable.

The prevailing winds of the Forth will be seen by the following table, constructed from observations taken every day at ten o'clock forenoon, on the island of Inchkeith, for the ten successive years ending on 31st December 1826.

Direction of the Winds.	Description of the Winds.				
	Light Airs.	Breezes.	Gales.	Storms.	Total.
South..............	96	165	29	2	292
South-west.......	42	181	111	5	339
West...............	275	807	267	22	1371
North-west.......	44	157	13	3	217
North.............	26	105	20	1	152
North-east........	68	90	23	24	205
East...............	334	345	34	26	739
South-east........	104	109	6	5	224
Changeable.......	101	12	...	...	113
	1090	1971	503	88	3652

Nearly the same facts are better brought out by the following table, constructed from the observations taken every day, in the Calton Hill observatory, under the superintendence of the astronomical observer, for the same ten years, ending on the 31st December 1826. The entry in the register for each day is applicable to the winds of its whole twenty-four hours.

Direction of the Winds.	Description of the Winds.						
	Moderate and Calm.	Brisk.	Sharp.	High.	Very High.	Extremely High.	Total.
South	85	2	...	17	3	4	111
South-west	310	43	1	178	68	30	630
West	444	54	3	235	54	8	798
North-west	207	33	4	143	48	9	444
North	61	6	4	17	5	...	93
North-east	122	11	2	21	2	...	158
East	381	37	4	45	4	...	471
South-east	131	8	3	14	2	...	158
Changeable	588	44	4	119	29	5	789
	2329	238	25	789	215	56	3652

From these tables it will be observed, that the prevailing winds in the Forth, the gales and storms at Inchkeith, and the very high and extremely high winds at the Calton Hill observatory, chiefly proceed from westerly directions.

The waters of the Forth and its tributary streams are all fresh until they mingle with that of the ocean. Long before the river becomes two miles wide, they acquire a saltness which differs little, if at all, from that of the sea in general. The water in the neighbourhood of the coal-works of the Forth has been often evaporated for the sake of the salt, which was here at one time an extensive article of manufacture.

The constituent parts of 10,000 parts of the waters of the Frith were found by Mr Murray,[1] in the course of three different analyses made in different ways, to contain,

Muriate of soda	242·51	245·04	220·01
Sulphate of magnesia	7·86	17·04	...
Sulphate of soda	9·99	2·66	33·16
Muriate of magnesia	34·49	28·63	42·08
Muriate of lime	...	...	7·84
Sulphate of lime	9·45	9·72	...
	304·30	303·09	303·09

Mr Murray placed most confidence in the results obtained from the last of these analyses.

The minerals of which the banks of the Forth are composed will be found described under the counties of East-Lothian, Mid-Lothian, West-Lothian, Stirling, Clackmannan, Perth, and Fife, by all which the Forth is bounded.

Coal, besides being wrought in these counties, was once worked near Culross and Torryburn, under the bed of the river, and partly by pits within high-water mark. At the mouths of these pits there were piers, at which vessels were loaded with the coals. But these mines have been for many years filled with water.

The bed of this river consists to a great extent of mud, and in many places the freestone bottom is covered with it to the depth of twenty feet. Its banks above Alloa, and a great way below that place, are formed of this material, which is brought down by the waters from the higher levels; and the carses of Stirling and Falkirk, &c. which have been formed from its accumulation, are secured at their lowest levels by sea-dikes against inundations, occasioned by the rise of the tides.

The recent alluvial cover to the westward of Alloa has been found by Mr Bald in some places to be no less than ninety feet deep, and to contain trunks and branches of large trees, and beds of sand with sea shells, particularly of the oyster, cockle, mussel, donax, &c.; and similar beds of shells not only abound at and below Alloa, but are found several miles to the westward of Stirling similarly situated. Many of the oyster-shells are of uncommon thickness, and larger than any specimens that can now be found. What makes the westerly position in which these uncommonly large shells are found very remarkable is, that there are no specimens of the oyster now found farther up the Forth than Queensferry.

There is also a bed of marine shells on the banks of the Forth near Borrowstownness, about three miles in length, and several feet in thickness, and which is situated many feet above the present level of the waters of the Forth. This circumstance would favour the opinion that the sea in this quarter had at one time occupied a higher elevation than at present; an opinion which is further supported by the fact of the skeleton of a large whale having been found some time ago in the lands of Airthrey, near Stirling. The surface of the ground where the remains of this huge marine animal were deposited, was ascertained by Mr Stevenson to be twenty-four feet nine inches above the present level of the Forth at high water of spring tides.

But if the land has been gaining on the waters in the upper part of the Forth, ground has been lost farther down the estuary. The sea has made considerable encroachments at North Berwick; at Newhaven, an arsenal and dock built in the reign of James IV. in the fifteenth century has been swept away; and on the coast of Fife, in 1803, the last remains of the Priory of Crail, and the ground on which it stood, met with a similar fate.

At Largo Bay the sea seems now to be covering ground which was formerly dry land. Here a submarine forest has been discovered, the roots of the trees penetrating into a brown clay, over which is irregularly distributed a covering of sand and fine gravel. The peat upon it is composed of land and fresh-water plants, amongst which are hazel nuts, and the remains of birch, hazel, and alder trees. The root of one tree, apparently an alder, was here traced by Dr Fleming to an extent of more than six feet from the trunk.

There is an abundant supply of sea-weed on almost all the shores of the Forth, which has often been burned at various places to form kelp. Within the last twelve or fifteen years this manufacture in the Forth has been entirely given up. The produce of the rocks, or what is cast ashore in storms, is now therefore only used as manure.

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[1] *Edinburgh Phil. Trans.* viii.

Seals are often seen sitting on the rocks, or swimming along the coasts of the Forth. Sharks are also said to have occasionally made their appearance. Numerous cetacea from twenty to sixty feet long, and grampuses, have often been stranded in the Forth. A male Beluga, or white whale, apparently of full growth, appeared in its waters in 1815. It was killed by the salmon fishers near the abbey of Cambuskenneth, and sent to Edinburgh, where it was dissected by the late Dr Barclay.

Numerous porpoises are often observed tumbling and disporting in the Frith. The salmon is abundant, and salmon fisheries have been established at Stirling, Abercorn, and near Queensferry, &c. Herrings are also plentiful, and at Burntisland and various other stations the fishery is prosecuted successfully. The other fishes caught in the Forth are mackerel, haddock, cod, turbot, skate, flounders, halibut, soles, &c. In fact, fish are so abundant in the Frith, that upwards of forty sail of foreign vessels are said to have been frequently seen fishing on the cod banks opposite St Abb's Head, guarded by a Dutch ship of war. Almost all parts of the Frith are also fished with success by English vessels. Sometimes a dozen at a time of the English fishing smacks are there seen busily employed. One of them alone has been known to catch seventy-two scores of large cod in two days. Taking this as an average, and it is said not to be a high one, these vessels in a week would catch 52,000 of the finest fish, which is a much larger quantity than is believed to be sold in the Edinburgh market during a whole year. This market is chiefly supplied by Newhaven and Fisherrow boatmen, who purchase their fish generally from fishermen residing at a distance upon the coasts of the Frith, many of whom are under contracts with English fishmongers for the supply of the London markets.

Cellardike is one of the principal stations of this fishery in the Forth. It supplies the London market to a great extent with salted cod, and Glasgow as well as Edinburgh with fresh fish; but here, as elsewhere in the Forth, the fishermen migrate for months to the herring fishery in the north of Scotland, at the season when fish is most abundant, particularly the haddock. This interrupts the regular supply of that important article. Lobsters and crabs are also caught at almost all the fishing stations in the Forth. Mussels, cockles, lampits, and wilks, are also collected in great quantities at those places where they abound; and oysters are extensively fished at the oyster-beds, which are met with chiefly to the eastward of Leith.

There is nothing remarkable about the wild fowl resorting to the Forth in winter. The solan geese of the Bass have been already described under that head, to which the reader is referred.

Besides the Bass, there is another island in its neighbourhood, the May; and the larger islands farther up the Forth are Inchkeith, Inchcolm, and Inchgarvey, which will be found described in separate articles. The smaller islands are Fidra, the Lamb, and Craigleith, near the Bass, and Mickry and Cramond Islands near Inchcolm.

The principal sand banks which obstruct the navigation of the Forth are the Drum Sands near Cramond, and the Sandend to the east of Burntisland. The principal rocks which require to be avoided by the mariner are the South Carr reef lying N.N.W. from Dunbar, the North Carr about a mile and a quarter east of Fifeness, the Blea to the west of Kinghorn, the Commons to the west of Burntisland, Craig Waugh S.E. $\frac{1}{2}$ E. of Inchkeith, and the Gunnet Rock, Pallas Rock, Longcraig, Briggs, and Harwit, in its neighbourhood; and several miles farther west, and nearer Inchcolm, the Oxcares, Carcraig, and Mickry Stone.

Many of these rocks are seldom seen at the lowest ebbs; their position, together with the different landmarks which are necessary to point them out to the mariner, are well delineated on an admiralty chart of the Forth by Captain Thomas, of the navy, published in 1815.

To show their position still better, floating buoys have been placed upon Craig Waugh, the Gunnet, the Harwit, and the Pallas rocks, and beacons have been erected on the Oxcares and the North Carr. The last was completed in 1821, with a cast-iron ball formed in ribs, and is elevated upwards of twenty-five feet above the medium level of the sea, the under part of the beacon being a circular building of masonry of eighteen feet in diameter.

Besides these provisions for aiding the navigator, there is a lighthouse on the Isle of May. It has been lighted since the 1st of February 1816, during night, with oil; and, by means of reflectors, gives what is called by mariners a stationary light. Being defended from the weather in a glazed light roof, it has a uniform steady appearance, resembling a star of the first magnitude, and is seen from all points of the compass to the distance of seven leagues. In 1804, another lighthouse was erected on the summit of Inchkeith. Its lanthorn is 229 feet above the level of the sea, of which the building forms forty-five feet. On the 1st of February 1816 it was converted into a revolving light without colour, seen from all points of the compass, and exhibiting a bright light once every minute, and becoming less luminous, till to a distant observer it totally disappears. By this arrangement the possibility of mistaking Inchkeith light for any other of the Forth is effectually prevented. There are also light-houses on the pier-heads of Leith, Newhaven, Burntisland, Pettycur, Queensferry, &c. on which, whilst there is water in the harbours during night, care is taken to keep the lamps burning.

The harbours and landing places are, on the south side of the Forth, Dunbar, North Berwick, Port-Seton, Morison's Haven, Fisherrow, Leith, Newhaven, Trinity, Queensferry, Borrowstownness, and Grangemouth; and on the north side, Crail, Anstruther, Elie, Pittenweem, Leven, Methel, West Wemyss, Dysart, Kirkaldy, Kinghorn, Pettycur, Burntisland, Starleyburn, Aberdour, St Davids, Inverkeithing, Queensferry, Charleston, Crombie Point, Culross, Kincardine, and Alloa. The more important of these harbours and landing places will be found described in separate articles. The anchorage in the Forth is in general good, and in particular the anchorage at Aberlady Bay, in the westerly part of Largo Bay, and in the roads of Burntisland, Leith, St Davids, Limekilns, &c.

The coasting and foreign trade of the Frith is carried on in vessels varying in size from eighteen tons to nearly 500. The principal port to which they belong is Leith; but there are several whalers and vessels engaged in the Australian, American, Mediterranean, and Baltic trades, belonging to other ports in the Forth.

The traffic in goods and passengers between the ports in the Forth and London, Greenock, Glasgow, Liverpool, Hull, Newcastle, Dundee, Perth, Aberdeen, Inverness, Peterhead, and almost every considerable town in Scotland, is conducted chiefly by the vessels of joint-stock companies, which vessels sail periodically. A joint-stock company is also engaged in the Leith, Hamburg, and Rotterdam trades, the vessels belonging to which sail at present from Leith every alternate Tuesday. The Glasgow, Greenock, and Liverpool trade is chiefly conducted through the Forth and Clyde Canal; as to which, see NAVIGATION, *Inland*, and GRANGEMOUTH.

The names of all the vessels belonging to the Forth are registered in the custom-houses of Leith, Borrowstownness, Kirkaldy, and Anstruther. The aggregate tonnage registered at each of these ports will be found under the articles KIRKALDY and LEITH, together with a statement of the number of arrivals in a year from foreign ports and coastwise, and the chief goods and other articles landed and exported, with the aggregate duties paid upon them.

To facilitate the intercourse between the northern and southern parts of Scotland by a communication across the river Forth, wooden bridges near Stirling were erected at a very early period. The time at which the present old bridge of Stirling was erected is unknown; but it must have been built before the year 1571, as Archbishop Hamilton is then said to have been hanged over it by the king's faction under the Regent Lennox. The newest bridge at Stirling is of very recent erection. There was, within the last thirty years, a project of erecting a suspension bridge at Queensferry, and another project of making a tunnel near the same place; but the practicability of these schemes has been doubted.

From the want of such facilities of passage across the Forth, the regulation of its ferries became the object of legislative enactments at so early a period as the year 1467. Before the introduction of steam navigation, the traffic at these ferries was chiefly conducted by open boats, pinnaces, and yawls of various sizes; and from the want of low-water piers, they seldom departed from either side except at high water. Although by the statute 1686 all Scotch ferries were subjected to the regulation of the justices of the peace and commissioners of supply, the traffic on the Forth at all times received much interruption from not having stationary superintendents, and the consequent want of proper subordination.

Most of the ferries on the Forth are still private property. The private rights to the Queensferry passage were in 1809 purchased by parliamentary trustees, for upwards of L.8550; and these trustees, out of funds arising from a government grant, at first of L.13,525, and it is believed afterwards of L.2300, and loans from private individuals to as great an extent upon the security of the profits arising from the traffic, have improved the landing places, and purchased and continue to maintain suitable vessels. In 1828, the debts of this trust to banks and private individuals, with interest, amounted to L.16,410. 2s. 1d.

The rent payable by the tacksmen of the ferry, including an allowance of L.200 a year from the post-office, was then	L.1920	0	0
The expenditure, consisting of repairs on piers, vessels, feu-duties, interest of debts, and officers' salaries, &c. then amounted to	1615	9	0
Leaving a surplus of	L.304	11	0

The annual surplus since 1828 is understood to be rather greater than this, in consequence of the piers requiring but little repair. The amount of the traffic in 1833 was estimated at 6180 carriages and carts, 11,750 horses, 16,500 cattle, 27,000 sheep and lambs, 4500 barrel-bulk of luggage, 73,500 passengers, including 500 paupers allowed to pass gratis, and 3000 Highland shearers, and exclusive of mail guards and coachmen twice every day, and of military baggage and stores having a free passage. The number of passengers landed from, or taken off to, steam vessels passing up and down the Frith, at Queensferry, is estimated at not less than 4000.

The ferry stations of Burntisland and Newhaven were added in 1792 to the stations of Kinghorn and Leith, which had been used for the great ferry of the Forth from the very earliest period of our history; and by the act 32 Geo. III. cap. 93, the traffic in goods and passengers crossing the Forth between these stations was placed under the superintendence of trustees, with powers to raise tolls for the improvement of the harbours. These trustees obtained further powers from parliament in 1813 to purchase from the boatmen the vessels used upon these ferries, and to carry on the trade themselves exclusively both as to goods and passengers. In 1813 and 1821 they were further empowered by parliament to acquire rights to extend their monopoly in transporting passengers between Mid-Lothian, and Kirkaldy and Dysart on the opposite coast. They have tried both; but some years ago they abandoned the Dysart passage. By a loan from government to the extent of L.10,000, and from private individuals of L.19,516. 13s. 4d., besides a sum from the Navy Board, they have erected a stone pier at Newhaven, made small repairs, and added landing slips to the harbours on the north side; and they conduct the ferry to Leith at present by means of sailing vessels; and between Newhaven on the one side, and Burntisland, Kinghorn, and Kirkaldy, on the other, by steam navigation, their vessels making from three to four trips to and from each of these ports daily.

In 1832 the gross debts of this trust, with interest, amounted to	L.39,494	7	2½
Deduct their property in boats, stores, fixtures, &c. and their funds, valued at	16,081	7	6
Nett debt	L.23,412	19	8½

The revenue of the steam-vessel ferry to and from Newhaven in 1832 was	L.6,995	7	8½
Ditto of the sail-boat ferry at Leith, and Burntisland, and Kinghorn, for passengers, cattle, and goods, landed there	1,051	2	7½
Ditto of cutters and yauls, &c.	7	5	6
Royalty for Newhaven pier L.238. 14s. 2d. interest on bank accounts, towing vessels out of harbours, light-house revenue, &c.	401	13	5½
	L.8,455	9	3½

The steam-vessels' expenses in 1832 were	L.5,228	15	0½
Sail-boat expenses	1,077	2	11½
General charges of management, repairs on houses, and piers, light-houses, &c.	504	12	9
	L.6,810	10	9
Interest of loans	955	16	8
Allowance for deterioration of vessels by wear and tear	490	0	0
Total expenditure	L.8,256	7	5

From this statement there would appear to be a surplus revenue of L.199. 1s. 10½d. This arises from the steam navigation. The Leith ferry appears to be conducted at a dead loss.

The number of passages and passengers to and from Newhaven in 1832 was as follows:

	Passages.	Paying Passengers.	Free.	
			Military.	Poor.
At the ferries of				
Burntisland	2,363	19,898	80	58
Kinghorn	1,668	31,312	56	71
Kirkaldy	1,536	29,134	284	111
Total	5,567	80,344	420	240
At the ferries between				
Leith and Kinghorn	1,052	1,296		
Leith and Burntisland	631	858		
	1,683	2,154		

The revenue arising at the Burntisland and Leith ferry in 1832 from cattle and carriages was L.15. 18s. 1d., and from goods L.435. 17s. 8d. The revenue arising at the Leith and Kinghorn ferry during the same period from cattle and carriages was L.126. 7s. 6½d., and from goods L.363. 16s. 4d.

The revenue arising from the carriage of goods at the ferry between Leith and Kirkaldy is not known, as it is conducted by private traders, and is not within the limits of the trustees' monopoly. As little is generally known concerning the numbers of the passengers crossing in the steam-vessels which now regularly ply to and from Dysart, Largo, Queensferry, Cromby Point, Limekilns, Alloa, Stirling, Borrowstownness, &c. These vessels land and take in passengers regularly at the low-water Chain Pier at Trinity, which is a noble specimen of what may be done in the erection of useful works by private individuals for the benefit of the public.

The principal projects at present in contemplation for the improvement of these ferries, and in general for extending the navigation of the Forth, are the erection of low-water piers on both sides of the Frith.

Mr Telford, in October 1828, reported to government that it would cost L.38,660. 17s. 2d. to construct a low-water landing place at Newhaven in connection with the ferry pier, so as to secure a depth of water there of ten feet at low water; and that in proceeding farther westward he could not perceive that any advantages were to be obtained.

Another project, founded on a report by Mr Matheson, civil engineer, was to erect at Wardie Point, the property of Captain Donaldson Boswall, a complete landing place and a wet dock. At this place it is stated that at the distance of 1500 feet from the shore there is ten feet deep water at the lowest ebb of stream tides; but the accuracy of the statement has been questioned. The estimated expense of this proposed harbour and other structures is L.122,149.

A third project is that of a joint-stock company to erect at Trinity, to the east of Wardie, and nearer the Ferry Trustees' pier, including the ground whereon the chain pier now stands, a wet dock containing forty-three acres, and affording wharfage to the extent of 12,000 feet. It is proposed that the dock should be entered by a lock 200 feet in length and fifty-five in width, of sufficient dimensions to admit a ship of the line or steam-vessels of the first class. The entrance is meant to be protected by a breakwater 1100 feet long, parallel to the channel of the Frith, which, with two check piers built on arches, would secure an outer harbour 900 feet long by 300 wide, where there would be a low-water landing place; the depth of the water in the outer harbour at the lowest ebbs would be upwards of eleven feet, and twenty-nine feet at high water, and the depth over the whole dock would be only one foot less. The estimated expense of erecting these works, purchasing the grounds, &c. is stated to be L.250,000. Application has been made to parliament for power to carry this project into execution.

A fourth project is that of his grace the Duke of Buccleuch, who, with a munificence seldom displayed by a single individual, has come forward with a proposal to construct at his own expense a deep-water harbour on his property at Granton. This situation is about three quarters of a mile west from the Trinity Chain Pier, in a small bay formed by Granton Point on the west and Wardie Point on the east. Here a depth of twelve feet of water is obtained at low water of spring tides, at the distance of 550 yards from high-water mark, the rise of the tide giving twenty-eight feet at high water of spring tides. It is proposed to extend two piers of masonry to this depth, including between them an area of thirty-five acres, which will be occupied as an outer harbour or receiving basin, and capable of accommodating his majesty's ships of war as well as the largest class of merchant vessels. To the landward of this basin it is proposed to construct a suite of wet docks, to such an extent as may afterwards be found necessary. It is calculated that the expense of each of the piers will be from L.80,000 to L.90,000, and that the wet docks will cost at least L.100,000 more.

The erection of low-water piers on the south side of the Forth, at any of the stations above referred to, should only take place if it be found to be utterly impracticable, by a capacious tide basin, or otherwise, to deepen the harbour of Leith, or secure at that station a sufficient depth of water at the lowest ebbs. At the same time the erection of low-water landing places on both sides of the Forth is now considered by every body as an object of the greatest national importance; and when the relative merits of new grants out of the public funds for such works in distant colonies, or nearer home, come to be considered, it is to be hoped that the harbours on the Forth will receive proper aid from the government, and not be left to be improved exclusively by the enterprise and at the risk of private individuals.

On the north side of the Forth Mr Rennie had advised an extension of the present piers of Burntisland for a low-water landing place there. But Mr Telford recommended to government the construction of a landing pier a little to the eastward; the pier to be at the distance of 700 feet from high water, and carried in to ten feet depth of water at low water of spring tides. He estimates the expense at L.20,801. 9s. 3d. He also recommends a continuation of the road partially made along the beach from the eastward of Burntisland, so as gradually to rise from the eastern extremity of that parish to the town of Kinghorn. But in the event of Kinghorn being preferred as the better of the two stations on the Fife side for a low-water harbour, Mr Telford also reported to government that he would propose to form a very capacious harbour in the bay of Kinghorn, by making an insulated break-water, and a smaller one connected with the Kinghorn Kirk Craig, having an opening between them, and a main landing pier slip on the western side of the harbour. He estimates the expense at L.60,917. 3s.

Another survey and report was obtained at the same time from Mr Buchanan, civil engineer. Mr Buchanan reported that a pier of solid masonry might be carried out 1200 feet on the ridge of rocks stretching from the Kirk Craig, so as to form a harbour which would command a depth of water at the entrance of ten or eleven feet at the lowest spring tides, and of twenty-six feet at high water of ordinary spring tides. This would inclose a space of twenty imperial acres in extent, secure from every storm. He estimates the expense at L.20,159. 14s., and the expense of a level road from it to Kirkaldy, the great seat of the traffic, at L.3960, and that of a railway upon it to the same place at L.2760. 15s. Indeed, the roads to Burntisland and Kirkaldy, referred to in both Mr Telford's and Mr Buchanan's reports, are admitted to be indispensable at whatever station proper landing places are erected.

FORTIFICATION.

Fortification is the art of putting a town or place in such a posture of defence as may enable a comparatively small number of men within to resist, for a certain period of time, the attacks of a numerous army without; or it may be more simply defined the art of putting a place in a state to resist the attack of an enemy.

Fortification may be divided into *Permanent*, or such works as are built round towns, and intended to remain; *Field*, or such as are only required to last for a battle or a campaign; *Defensive*, or the means of resisting attacks; and *Offensive*, or the various modes of attacking fortified places. And these may again be divided into *Regular* and *Irregular*, *Natural* and *Artificial*. Regular fortification is that which is constructed, according to the rules of art, on a figure or polygon which is regular, and has all its sides and angles equal. Irregular fortification, on the contrary, is that where the sides and angles are not uniform, equidistant, or equal, owing to the accidents of the ground, valleys, rivers, and the like. Natural fortification is the strength or capability of defence which nature herself has afforded to particular places by reason of their elevated situations and the difficulties of approaching them; as in the case of high and nearly inaccessible hills, steep rocks, morasses, and the like. Artificial fortification, on the other hand, consists of works so contrived and constructed as to increase the natural advantages of a situation, or to remedy its defects.

INTRODUCTION.

Fortification is very nearly as ancient as the existence of society. When men first assembled together for the purpose of mutual protection, and placed their habitations on the same spot, the law of necessity, springing in this case out of the principle of self-defence, rendered it indispensable for them to adopt some means for securing their families and their property against the sudden inroads of enemies. Hence, when Cain, the son of Adam, built a city, he surrounded it with a wall; and, in like manner, the Babylonians, when they built cities soon after the Deluge, encompassed them with similar defences. In the early ages, men considered themselves as sufficiently protected by a single wall, from behind which they could with safety discharge their darts, arrows, and other missiles, against an assailant. But when, in the progress of improvement, new and more powerful means of attack were discovered, it became necessary to increase, in a corresponding degree, the inert force of resistance; and accordingly the feeble defensive structures of the primitive ages were in time succeeded by solid ramparts, flanked and commanded by elevated towers. In short, as the power of attacking fortresses or places of strength was augmented by successive devices and inventions, the means of resistance were proportionally increased, until the art of fortification arrived at a state of comparative perfection, in which it remained for many ages nearly stationary.

The various improvements which were from time to time made in strengthening the walls, and adding to the defences of ancient cities, are recorded in history, and need not be detailed in this place. The first walls which we read of consisted of brick, the material employed by Cain for the protection of the city which he founded, and called by the name of his son Enoch. Amongst the ancient Greeks, brick and rubble stones intermixed were used for the same purpose, as we find from the description of the wall which connected Mount Hymettus with the city of Athens. The walls of Babylon and Nineveh indicate a prodigious advancement in the art of fortification, and are justly accounted amongst the wonders of the ancient world. Those of the former city, ascribed by some to Belus, and by others to Semiramis, were thirty-two feet in thickness, and a hundred feet in height, surmounted by towers at an average ten feet higher, and cemented by means of bitumen or asphaltum; they encompassed a vast area, and presented a solid defence, which no means of attack known in ancient times were sufficient to overcome or beat down. The walls of Jerusalem, though of smaller dimensions, appear to have been little inferior in strength and solidity to those of Babylon; for, in the siege of that capital by Vespasian, all the Roman battering-rams and other engines, though used with the utmost vigour, required a whole night to disengage four stones in the masonry of the tower of Antonia. But when fortification had arrived at the state in which we find it in the works of these and other cities, it remained stationary for ages, and perhaps even retrograded somewhat, until the discovery of gunpowder, the invention of artillery, and the application of both to military purposes, effected an entire revolution in the principles of attack and defence. Then the round and square towers, which had formed secure flanking defences against assailants armed only with arrows and with darts, afforded no protection against the projectiles discharged by cannon; and even those battlements which had defied the catapult and the battering-ram speedily yielded to the force with which they were now assailed, whilst their defenders were at the same time destroyed, or buried in their ruins.

It being thus found that the ancient system of fortification was of little or no avail against the new method of attack which had been discovered, and which came into general use towards the close of the fifteenth century, it became indispensably necessary to adopt another method of defence. The plan of fortifying with bastions is supposed to have commenced with the Italians early in the fifteenth century. The bastions on the enceinte of Verona, built by the Italian engineer Micheli, in the year 1523, are generally supposed to be the oldest extant; and the next, probably, are those still to be seen at Antwerp, and which were constructed by the Emperor Charles V. in the year 1545. These bastions are small, with narrow gorges and short flanks and faces; and they are placed at a great distance from one another, it being the invariable practice, at the time when they were built, and for a considerable period afterwards, to attack the curtains, and not the faces, of the bastions.

Errard of Bois-le-duc, one of the principal officers of the engineer corps employed by Sully, prime minister of Henri IV. was the first in France who laid down rules respecting the best method of fortifying a place, so as to cover its flank. At the command of the minister, he wrote a book on the subject, which was published in 1594, and in which the details of his method are explained. Errard fortified inwards; and in the square, pentagon, hexagon, heptagon, and octagon, he made the flank perpendicular to the face of the bastion; but in the enneagon, and in all polygons of a greater number of sides, he made it perpendicular to the curtain. In endeavouring to accomplish his object, however, he made the gorges too small, the embrazures too oblique, and left the ditch almost defenceless. This engineer constructed part of the enceinte of the citadel of Doutens, as well as the citadel of Amiens, and also some works at Montreuil and Calais.

The Chevalier Antoine de Ville, who succeeded Errard, published a treatise, dated 1629, in which he completed much that his predecessor had only sketched, and rectified various defects in the method of the latter. The Chevalier was employed under Louis XIII. and constructed new enceintes for Montreuil and Calais. His plan of fortifying has been denominated by some the French method, and by others the Compound System (*Système à trait composé*), because it united the Italian and Spanish methods, from the latter of which it differs only in having no second flanks and fichant lines of defence, and in not confining the flanked or salient angle of the bastion to ninety degrees. The leading maxims of the Chevalier de Ville were, to place the flanks perpendicularly to the curtain, to make them equal to the demigorges, or each equal to a sixth part of the side of the interior polygon, and, in the hexagon and all higher polygons, to confine the flanked angle to ninety degrees. But this plan is liable to nearly the same objections as that of Errard; for here, also, the embrasures are too oblique, especially in the polygons, and the ditch is necessarily but ill defended.

Sixteen years after the publication of De Ville's treatise appeared the work of the Comte de Pagan, which issued from the press in 1645, and contained the development of a system which, in a short time, entirely superseded those of his predecessors. In fact, it was the Comte de Pagan who first disengaged the science of fortification from a number of suppositions which custom had in some measure consecrated, and which, resting more on abstract mathematical reasoning than on practical observation and experience, had hitherto retarded the progress of the art. This engineer acquired great reputation during several sieges which he assisted in conducting under Louis XIII.; but having become blind at the age of thirty-eight, he was obliged to retire from the service, in which he had already obtained the rank of mareschal-de-camp, and he died six years after completing the treatise above mentioned, in which he embodied a full exposition of his system. The Comte de Pagan made the flank perpendicular to the line of defence, in order as much as possible to cover the face of the opposite bastion; and he also pointed out a method of building casemates in a manner peculiar to himself. Vauban borrowed from the Comte de Pagan the length of his perpendicular, and Allain Manesson Mallet, whose construction still remains in favour with many, also proceeded upon the principles laid down by this scientific soldier.[1]

The Mareschal de Vauban was born in 1633; and in 1655, at the time of the Comte de Pagan's death, he had already acquired reputation at several sieges. Vauban followed up the principles suggested by Pagan, and employed them extensively in practice, with consummate skill and judgment. He constructed thirty-three new fortresses, repaired and improved one hundred; and having conducted about fifty sieges, he left his extensive works, and a treatise *De l'Attaque et de la Defense des Places*, published in 1737, to speak for themselves. From the different constructions observable in these works have been compiled the systems which, in the military schools, are denominated Vauban's first, second, and third systems of fortification, and which the reader will find developed in the sequel. Had the genius of Vauban been applied to the discovery of a method for securing a permanent superiority to the defence of fortified places, posterity would have been greatly indebted to him, and even humanity would have had cause to rejoice in such a triumph of military art. But, being engaged in the service of the most ambitious monarch of modern times, Louis XIV. he applied his great talents to forward his master's views, and soon perfected that irresistible system of attack,[2] which has ever since been so successfully followed. Before his time the general superiority was on the side of the defence; but ever since, the case has been so completely reversed, that the success of an attack made with adequate means, and scientifically conducted, is a matter of absolute certainty.

M. Minno Baron de Coehorn, first a general of artillery, then a lieutenant-general of infantry, and ultimately director-general of all the fortified places belonging to the United Provinces of Holland, was the contemporary and rival of Vauban. This able engineer, convinced that, however expensively the rampart of a town may be constructed, it cannot long resist the shock of heavy ordnance, invented three different systems for throwing such obstacles in the way of a besieging force, that, although the place be not thereby rendered impregnable, it can only be approached with great difficulty and hazard. But these methods are only applicable to low and swampy situations, such as are to be found in Holland, and are therefore not available where the localities are of a different or opposite description. At the same time, Bergen-op-Zoom, Manheim, and other places fortified by this engineer, particularly the two former, have very great merit, inasmuch as it is impossible for a besieger to penetrate into any of the works, without being exposed, on all sides, to the fire of the besieged, who are under cover; and from artillery and musketry it is scarcely possible for an assailant to shelter himself. Coehorn published a work on fortification before he had acquired much practical experience, and therefore did not follow it in fortifying Bergen-op-Zoom, which is allowed on all hands to be his masterpiece.

Since Vauban's time several improvements have been suggested, particularly by Cormontaigne, who entered the corps of French engineers in 1716, nine years after Vauban's death, and died a mareschal-de-camp in 1750. Some account of the system of Cormontaigne will be found in a subsequent part of this article. The three methods delivered by Belidor are all applicable to an octagon of two hundred toises; those of Scheiter, distinguished into great, mean, and little, in imitation of Pagan, require the exterior sides of the polygon to be, respectively, two hundred, a hundred and eighty, and a hundred and sixty toises. Steven, a Fleming who wrote on fortification, exemplified his method of construction on a hexagon. Fritach, a Pole, proposed two methods, which he exemplified on different polygons. Dogen, a Dutchman, published a large volume on fortification, in which, after enumerating various modes employed by different writers for determining the salient angle, he selected three as the most approved, and proposed as many methods of construction, one of which is borrowed from Fritach, the Pole. Pietro Sardi, an Italian, suggested a peculiar method of construction on a hexagon. The Sieur de Fontaine found the flanked or salient angle of the bastion by adding fifteen degrees to half the angle of the figure, from the square up to the dodecagon, in which last it becomes ninety degrees, and at this he continued it in all the higher polygons. He also constructed outwards, and, in every regular figure, made the curtain equal to seventy-two toises, the face of the bastion to forty-eight, and the flank, which he placed perpendicularly to the curtain, to eighteen toises, or a fourth part of the curtain. Ozanam and Muller delivered each four methods of construction, the particulars of which will be found in their respective works. In 1751, Charles Bisset, who as an engineer-extraordinary served with the Duke of Cumberland in the Netherlands, and was present during the siege of Bergen-op-Zoom by the Mareschal Lowendahl, published a treatise on the theory and construction of fortification, in which there are many sensible and judicious remarks; and the same general description may be applied to an *Essai sur la Fortification, ou Examen des Causes de la grand supériorité de l'Attaque sur la Defense*, published anonymously in 1755. In a work entitled *Science de la Guerre*, which appeared at Turin eight years before the date last mentioned, a new method of construction is proposed, in which the principal objects to be attended to are, that there be mines under all the works, and that a regular communication be kept up with the chambers by means of subterraneous galleries, to be resorted to in proportion as the enemy approaches the body of the place. The third volume of the *Œuvres Militaires* contains some useful observations and maxims relative to irregular fortification; and in the Supplement to the *Rêveries* of Mareschal Saxe, by Baron d'Espagnac, the subject of fortification generally is amply discussed, and an accurate description given of the different means of attack and defence.[1]

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[1] Mallet constructs outwards, making in every figure or polygon the demigorge equal to a fifth part of the side of the interior polygon or figure, the capital of the bastion equal to a third part of the same side, the curtain equal to three fifths or thrice the demigorge, and the angle of the flank equal to 98°. The faces of the bastions and the flanks are determined by the lines of defence, which are razant. From these data all the other lines and angles are easily found.

[2] See his work *De l'Attaque et de la Defense des Places*, passim.

Of the more recent treatises on fortification, by far the most elaborate and complete is that of M. de Bousmard, entitled *Essai Général de Fortification, d'Attaque et de Défense des Places, dans lequel ces deux Sciences sont expliquées et mises l'une par l'autre à la portée de tout le monde;* a work which enjoys a deservedly high reputation on the Continent, though it has hitherto been comparatively but little known in this country. It is remarkable for great accuracy and research, and may be considered as embodying in itself every thing that is valuable in connection with the subject of which it treats. M. de Bousmard's idea is, that officers of the line should be entitled to exercise those functions which have hitherto been universally reserved for officers of engineers; and he even goes so far as to ridicule the idea of the latter forming a separate body in the army. He is of opinion that every officer should, when required, be qualified to act as an engineer; and to furnish the necessary information for this purpose, he has entered into those minute details which are absolutely essential to be known in order to direct the construction of fortresses, and the works necessary for the attack or the defence of strong places, but which are not at all requisite in order to discern the influence of the one or to determine the nature of the other. Proceeding on the same principle, he has further hazarded some questionable opinions, and indulged in abstract and delicate discussions, which are certainly out of place even in such a work, and which appear but little calculated to benefit persons possessing only a superficial acquaintance with the matters forming the subject of these disquisitions. M. de Bousmard's work, therefore, though intended to serve as an elementary treatise on fortification, is much too elaborate and refined ever to be used as such, and also too expensive for the pecuniary means of a great number of inferior officers, whose instruction the author professes to have had chiefly in view. But to teachers of fortification it is altogether indispensable; and as long as the science and practice shall continue on their present footing, it will be deservedly considered as the most comprehensive and valuable work on the attack and defence, as well as the construction, of all kinds of fortification.[2]

With regard to Carnot's *Traité de la Défense des Places Fortes*, it was written to serve a temporary purpose; and the celebrity which it acquired on its first appearance has for some time been rather on the decline. The more prominent innovations recommended in this treatise were, first, an alteration in the trace or outline of the polygon; secondly, the suppression of the exterior revêtement of the covered way, known as the counterscarp; thirdly, the detachment of the scarp-wall from the rampart, and the construction of the latter without revêtement; fourthly, destructive personal conflict with the besiegers by means of frequent sorties; and, lastly, making vertical fire the basis rather than an accessory of the defence. With regard to the first of these proposals, all of which the reader will find very ably discussed in Jones's *Journals of Sieges in Spain and Portugal*,[3] we have only to remark, that by means of an increased expenditure for retrenchments and casemates, as recommended by Carnot, the strength of particular portions of the polygon may be increased; and that, if he has failed in tracing a perfect front, founded on the basis of Montalembert's system of casemated and reverse fire, he has at least rescued a valuable suggestion from unmerited neglect, and rendered an important service to science by directing the attention of military men to the means most likely to create a barrier against the growing powers of the attack.

The *Traité de Fortification Souterraine, suivi de quatre Mémoires sur les Mines*, by M. Mouzé, lieutenant-colonel of engineers in the French service, was published at Paris in 1804, and is justly considered as the most complete work on the subject it treats of which has yet been given to the public. Subterranean fortification is a branch of the art which, until a very recent period, was wholly neglected in this country, and in which our engineers are still far behind their brethren of the continent. We learn from Colonel Jones's work on the Peninsular Sieges, that the Duke of

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[1] Besides the writers above enumerated, may be mentioned the Chevalier St Julien, an able engineer, who published a method by which, he asserts, works may be constructed at a less expense, yet in such a manner as to render the defence or attack more formidable; Francisco Marchi, of Bologna, who furnished no less than a hundred and sixty different methods of constructing fortifications; Bombelle, who established three kinds of fortification, called the grand royal (*grand royal*), the mean royal (*moyen royal*), and the little royal (*petit royal*); Blondel, who published a system divided into two principal heads, the great and the little, whose exterior sides are respectively two hundred and a hundred and seventy toises; Donato Rosetti, a canon of Livorno, who wrote on the method of constructing works in what he calls *fortification à rebours*, or fortification in reverse, so denominated because the re-entering angle of the counterscarp being opposite to the flanked angle, it will, according to him, be necessary to attack it from the reverse side of other works; and Antonio de Herbart, major of artillery in the Duke of Wurtemburg's service, who published a treatise on fortifications with what he calls *angular polygons*. The treatise entitled *Nouvelle Manière de fortifier les Places, tirée des méthodes du Chevalier de Ville, du Comte de Pagan, et de M. Vauban, avec des Remarques sur l'ordre renforcè, sur les desseins du Capitaine Marchi, et sur ceux de M. Blondel*, which appeared in 1689, is full of strong reasoning, whence the author deduced a new system, but it contains little that is really original, though it gives numerous references to what had previously appeared, and disposes the different parts in a judicious manner. M. de Montalembert's system of casemated and reverse fire has been in part adopted in the splendid fortress of Alessandria in Italy, constructed under the directions of Napoleon.

[2] Fages-Vaumale, *Aperçu Générale et Raisonné sur la Fortification des Places.* Préface, pp. xiv. xv.

[3] Vol. ii. p. 131, *et seqq.*

Wellington's army in Spain was unattended by a single regularly-trained sapper or miner until late in the year 1813; and many valuable lives were sacrificed, from the want of these valuable, or rather indispensable auxiliaries.

SYSTEMS OF PERMANENT FORTIFICATION.

1. *Vauban's First System.*

Before commencing to draw a plan of fortification, it is usual to determine upon some polygon on which to describe it. In this figure, accordingly (see Plate CCXLVI. fig. 1), we have taken the angle of an octagon, and called the length of the side 360 yards.[1] In constructing a fortification, a figure is determined on, as near that of a regular polygon as possible, within which the enceinte or chain of main works is to be contained. The enceinte or body of the place consists of as many bastions, connected with curtains, as there are sides to the figure, and each of these is made as near 360 yards as possible, so that every part may be within range of such arms as are to be employed in its defence.

The *principal* or *outline* denotes the contour or line by which the first figure of the work is defined. This line is supposed to pass along the superior part of the cordon, and is that from which all the other parts of the work are set off.

The *exterior side*, or side of the polygon above mentioned as equal to 360 yards, is that upon which the front of the fortification is described, and it extends from the flanked angle of one bastion to the corresponding angle of the next, as AB. These lines are bisected, and a perpendicular, DC, is drawn from the point of bisection towards the place, its length being proportional to the extent of the exterior side and adjacent angle of the polygon; that is, one sixth for the hexagon and all figures of a greater number of sides, one seventh for the pentagon, and one eighth for the square.

The *lines of defence* AEG, BEH, are drawn from the extremities of the exterior sides through these points, and produced to an indefinite length; and upon the lines so drawn are set off two sevenths of the exterior sides, equal to 102$\frac{6}{7}$ yards, which marks out the point for the shoulder of the bastion E and F. The distance between these points is then laid along the continuation of each line of defence, and a line is drawn connecting them for the curtain GH, from the extremities of which lines are drawn to the point marked off for the shoulder of the bastion, and thus form the flanks. And in this manner is drawn a front of fortification, which being repeated round the sides of the polygon, completes the works of the enceinte or body of the place.

Vauban divided his first system into three parts; namely, the little, the mean or intermediate, and the great. The first he used for small forts of four or five sides, citadels, horn-works, and crown-works, making the exterior sides from 120 to 240 yards, the perpendicular in the square equal to one eighth, and in the pentagon one seventh, and the faces of the bastions in each equal to two sevenths of the exterior side. In the mean or intermediate, which is adapted for all sizes of towns, the exterior side varies from 250 to 360 yards, the perpendicular is one sixth, and the faces are two sevenths. In the great the exterior side varies from 360 to 520 yards. This kind was never adopted for *all* the sides of a place, but only when *one* of these happened to be near a river or a marsh; in which case the distances of the bastions should be so regulated that they may not be out of musketry range from one another. When the curtain becomes unavoidably too long, this defect is in part remedied by erecting on it a flat bastion, which is not so high as the rest of the works.

Ground which will admit of being regularly fortified throughout is seldom or never to be met with, but, nevertheless, the rules of regular fortification must be observed as nearly as possible; that is, the flanked angles should not be less than 60°, the lines of defence should not exceed musket range, and the sides should be lengthened or shortened so as to obtain a well-proportioned front upon each. After an irregular place has been reduced to as regular a form as possible, lines are drawn parallel at the distance of about thirty yards from the houses, in order to give sufficient space for the rampart; and these lines form the interior polygon, which may be fortified inwards by setting off the demigorges of the bastions, and raising their flanks at an angle of 100° with the curtain: Or, the exterior side may be formed and fortified inwards by drawing a line parallel to each of the interior sides; and when the angle is that of a polygon of more than five sides, the distance from the exterior to the interior sides should not be less than 100 yards. If a side extend from 360 to 520 yards, the perpendicular should be diminished to about fifty yards, and the faces of the bastions be made from 100 to 120 yards. When a side is very long, it may be divided into several parts of from 340 to 360 yards each, which may be fortified with flat bastions.

The *ditch* or *fosse* is an excavation of from twelve to twenty-four feet in depth, and from thirty to fifty yards in breadth, surrounding the rampart on the exterior side, and the earth dug out of which serves to raise the rampart and parapet. The side of the ditch next the place forms part of the *escarpe*, the side next the country is called the *counterscarp*, and it is made circular opposite the salient angles of the works. In fig. 1 arcs are described with a radius of thirty yards, opposite the salient angles of the bastions, tangents to which are drawn upon the shoulders of the neighbouring bastions, and thus form the ditch. The general dimensions of a ditch should be such that its excavation, or deblai, would produce sufficient earth, or remblai, for the formation of the works. The breadth varies from thirty to fifty yards, in order that, in passing across it to the assault, the enemy may, for a considerable time, be exposed to the fire of the works; and its depth must also be such as to render difficult the escalade of the parapet, as well as to prevent the besiegers at the crest of the glacis from being able to see to breach the lower part of the revêtement of the escarpe. The line of the counterscarp is drawn from the rounding at the salient angles of the bastions upon the shoulders of the bastions next adjoining, in order that the whole of the ditch may be defended by the fire of the flanks of the collateral bastions. Ditches are of three kinds; wet, dry, and such as may occasionally be rendered either wet or dry. The wet ditch is calculated to prevent sudden surprises or assaults, excepting during hard frost, as in the attempt made to surprise Bergen-op-Zoom in the year 1814; but, independently of this exception, the number of bridges of communication, which require continual repair, and the difficulty of making sorties, which a wet ditch creates, render it extremely inconvenient. A dry ditch, which is capable of containing works for its own defence, and by means of which communications round the works may more easily be maintained, is therefore preferable to a wet one; but the third kind, which unites the advantages of the other two, should, when practicable, be preferred to either. It is only in particular situations, however, that the advantage of such a ditch can be obtained.

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[1] Although it has been common to employ the French toise as the standard measure for drawing plans, yet as the British lineal measure of yards and feet has of late years been adopted by our engineers, we shall conform to the same usage.

The *tenaille* is a work placed in front of the curtain. It is formed by the continuation of the lines of defence, at the distance of ten yards from the angle of the shoulder; the ends are then drawn parallel to the flanks of the bastions; it is made sixteen feet broad; the angle formed by the meeting of the two lines which determine its rear is then cut off, at the distance of ten yards, parallel to the curtain; and another line is drawn, at the distance of sixteen yards, parallel to this, and forming a small curtain upon the line of defence or front of the tenaille. The relief or height of the tenaille is determined by that of the neighbouring flanks, and it has a parapet of seven or seven and a half feet in height, and from twelve to fifteen feet in thickness. The use of the tenaille is to cover the postern gate, which is often made in the curtain or flank; when the ditch is dry, to protect the troops who may be formed behind the work for the defence of the ditch; and when the ditch is a wet one, to cover the boats which may be collected for the same purpose. It also serves to augment the defence, as its fire, from being more horizontal, and nearer than that from the flanks, is of course proportionally more effectual.

The *ravelin* or *demilune* is a work constructed opposite the curtain, and composed of two faces meeting in an outward or salient angle, with two demigorges formed by the counterscarp. Its use is to cover the curtain, the gates, and the flanks of the bastion. The ravelin is constructed as follows: Ten yards are set off along the faces of the bastion; from the shoulder an arc is described from the curtain, upon the perpendicular produced, with a radius of 160 yards; from this intersection lines are drawn bearing upon the points set off at ten yards from the shoulders of the bastion, but not further than the lines of the counterscarp, and at the intersection of the lines of the counterscarp or re-entering angle; and six yards are set off on the capital or line bisecting its angle, whence lines are drawn parallel to the lines of defence till they meet those of the counterscarp. Stairs, called *pas-de-souris*, are constructed here in order to facilitate the entrance of the ravelin from the ditch. The ditch in the ravelin, which is twenty-four yards in breadth, is made circular at the salient angle, and drawn parallel to the faces till it joins the main ditch.

The *covered-way* is a space of ten yards in breadth, extending all round the counterscarp of the ditch, and covered by a parapet of from seven to nine feet in height, with a banquette. The superior part of this parapet forms a gentle slope towards the country, which terminates at the distance of from forty to seventy yards; and this slope is called the *glacis*. The covered-way serves for drawing up troops in order to make sorties, and costs less than any other part of the works in proportion to the difficulty of taking it. In the salient and re-entering angles of the covered-way spaces are contrived which have been denominated *places of arms*.

The *salient places of arms* are formed by the circular parts of the counterscarp, and the prolongation of the branches of the covered-way till they intersect. The *re-entering places of arms* are constructed with two faces, forming a salient angle of 100° with the covered-way. The demigorges of the re-entering places of arms are generally from twenty-four to thirty yards; but when they are intended to contain a redoubt or entrenchment, they are from forty to forty-eight yards. The re-entering places of arms are meant to flank the branches of the covered way, and to contain the troops for its defence. The salient places of arms also serve for assembling the troops destined to defend the covered-way.

Traverses are constructed across the covered-way, upon the prolongation of the sides of the ravelins and bastions, perpendicular to the line of the counterscarp; they are from eighteen to twenty feet thick, and serve to cover the troops from the enfilading fire of the enemy. Other traverses should be constructed between these, so that the distance from the one to the other should not exceed thirty-six or forty yards. Openings are cut into the parapet of the covered-way about ten or twelve feet wide, in order to keep up the communication from one part to another round the ends of the traverses, which, however, may be shut by a gate when required. In the more improved systems of Cormontaigne and others, these passages are constructed in such a manner that each can be defended by the fire from the traverse in rear of it.

The *glacis*, as already stated, forms a gentle slope or declivity from the parapet of the covered-way towards the country, and varies from forty to sixty yards. Its parapet cannot be ruined by the fire of the enemy; it covers the revêtement of the body of the place; and being an inclined plane, it can be easily seen and defended from any part of the works.

The *rampart* is an elevation of earth, being the part of the works situated next to the town. It must be thick enough to receive a mound of earth, called the parapet, and also leave sufficient space behind it for working the guns, as well as room for the defenders to pass round freely. The ditch is immediately in front of the rampart, the faces of which are reveted or built up with stone walls, backed interiorly, at every fifteen or twenty feet, by buttresses or counterforts of masonry, to strengthen it. The rampart is divided into the *interior slope*, the *terre-plein*, the *banquette*, the *parapet*, and the *exterior slope* or *escarpe*. See fig. 4, *profile*.

The *revêtement* or face of masonry around the work on both sides of the ditch is intended to prevent the earth forming the rampart from falling into the ditch. To ascertain the proper thickness of masonry for this purpose has always been a work of considerable trouble and difficulty. Colonel Pasley of the royal engineers has given the following rules: 1*st*, For full scarped revêtements without berms, and for demi-revêtements having berms equal to one fourth the height of the masonry, the thickness of the wall should be seventeen sixtieths, and the length of the counterforts or buttresses one fifth of their height. 2*dly*, For demi-revêtements without berms, the mean thickness of the wall should be three tenths, and the length of the counterfort one fifth of the height. 3*dly*, For counterscarp revêtements, having only to retain simple terre-pleins, the mean thickness should be one fourth, and the counterfort one sixth of the height. In all these cases, Colonel Pasley supposes the revêtement to be countersloped, that is, to have the exterior slope in a vertical plane, and the interior face inclined, so that the base of the wall may be broader than its upper surface by one fifth of its height; and he also supposes the counterforts to be rectangular, and the intervals between their centres to be equal to four times their width. 4*thly*, He recommends that the foundations be made deeper in rear than in front, and that the courses of masonry form an angle with the horizon of about 10°; and, excepting at the exterior points, where it should be made horizontal, to prevent the rain from penetrating, that the interior face of the wall should be of an irregular form. In order to diminish the lateral pressure of the earth against the revêtements, several tiers of arches may be built between the counterforts in the form of segments of a circle.

The *cordon* is a round projection of stone, about a foot in diameter, which goes quite round the revêtement wall near the top, and serves to throw the drip of rain off the face of the masonry. It is also a considerable obstacle to besiegers, in placing their ladders for escalade against the escarpe.

The *profile* or *section* of Vauban's first system is given in Plate CCXLVI. fig. 4, in order to illustrate the relative relief or height of the respective works, and also to show the command which each has over the others. By *command* is meant the vertical height of one work above another, or above the country. When the height of the rampart, including that of its parapet, is twenty feet, and that of the parapet of the covered-way is nine feet above the plane of the site, then the rampart will have a command of twenty feet over the country, and eleven feet over the crest of the covered-way; and the latter, again, will have a command of nine feet over the field. There are three sorts of command, namely, in front, in rear, and in enfilade. That in front is when any eminence directly faces the work which it commands; that in rear is when the eminence is behind the work; and that in enfilade is when the eminence is situated laterally on the prolongation of any line or work. The last, which is the most dangerous kind of command, is best remedied by raising the salient works exposed to it, or by erecting traverses. In drawing this figure, a line, called the line of site, and supposed to be the surface of the ground on which the fortification stands, is drawn, and perpendiculars are erected on it equal to the respective heights of the different parts of the works corresponding to the lines in the figure. Thus *a* shows the terre-plein of the rampart, *b* the banquette or step to enable the soldiers to fire over the parapet, *c* the parapet, *d* the revêtement, *e* the escarpe, *f* the counterscarp, and so on.

2. *Vauban's Second and Third Systems.*

Having thus endeavoured to explain, with as much minuteness as possible, the principles of Vauban's first system, we trust, from what has been said, that no great difficulty will be experienced in understanding the methods of other engineers who have constructed works varying but little in the main from those prescribed by this system, whilst even these varieties have arisen from difference of situation and local peculiarities, more than from any other cause. The same general observation, indeed, applies to the other methods of construction followed by Vauban himself, who, in his second and third systems (see Plate CCXLVI. fig. 2) merely modified, according to circumstances, the principles upon which the first is based. When this celebrated military engineer was called upon to repair or improve the fortresses of Landau, Brisach, and others, and found these places already surrounded with strong walls surmounted by small towers at the angles, he did not, as some might have supposed, proceed to destroy these defences, but, with his accustomed judgment and ability, he immediately took advantage of them, and constructed, nearly in the same proportions as in his first system, large counterguards or bastions in front of the towers which crowned the angles of the wall. And by this method an important object was attained; for, as in front of each tower, or rather tower-bastion, there ran a ditch which cut off all communication between it and the counterguard, so the enemy, even if they should have succeeded in establishing themselves in the counterguard, would still have another ditch to cross, and another wall to breach, before they could attempt to give the assault.

There is so little difference between the second and third systems of Vauban, that a description of the former will be sufficient to enable the reader to distinguish and appreciate the peculiarities of the latter. In the second system, the interior side of the polygon, from the centre of one tower-bastion to that of the next, is supposed to be equal to 240 yards, and from its extremities, at the distance of twenty-four yards, perpendiculars are erected equal to thirty-six yards, for the flanks of the tower-bastions. A line is then drawn parallel to the interior side AB, till it meets the oblique radius of the polygon, or line drawn from the centre of the polygon, bisecting its angle, and this being done on both sides of the angle, forms the tower-bastion. The oblique radius is then produced seventy-eight yards, and lines of defence are drawn to the angle where the tower-bastion joins the curtain or line AB. On these lines of defence, the faces of the counterguard, or exterior bastion, are set off equal to . . . yards, and from the point forming the shoulder, flanks are directed to a point set off on the line AB, at the distance of seventy yards from its extremities. From the salient angles of the tower-bastions arcs are described with a radius of fourteen yards for the breadth of the ditch, and tangents to these arcs are drawn parallel to the faces of the tower-bastion, but stopped where they would meet a line drawn from the salient angle of the tower-bastions, at the distance of twenty yards from the flanks.

The *tenaille* is the same as in the first system, excepting that, at its ends, it is carried down till it meets the line drawn between the flanked or salient angles of the tower-bastions. The *ditch* in front of the counterguards, or, in other words, the main ditch, is constructed in the same manner as in the first system. The *ravelin* is formed by setting off ninety yards from the re-entering angle of the counterscarp, and directing its faces to points set off on the counterguards, at the distance of twenty yards from the shoulders. A flank is formed by cutting off the corners of the ravelin at the distance of fourteen yards on its demigorge, and twenty on its face; and this flank serves for the placing of guns in such a manner that their fire may be directed into the counterguard, or into the ditch before them, as occasion may require. Again, at the distance of forty-eight yards from the re-entering angle of the counterscarp, lines are drawn parallel to the faces of the ravelin for the *redoubt;* a ditch is formed in front of this, and parallel thereto, about eighteen feet in breadth; and the redoubt thus constructed has a command of four feet over the parapet of the rampart, as the tower-bastions have over the counterguards. The *covered-way* and *glacis* are formed as in the first system. It sometimes happens that redoubts are constructed in the re-entering places of arms; in which case their demigorges are made from fifteen to forty yards, and their faces set off at an angle of a hundred degrees, as before.

3. *Cormontaigne's System.*

The difference between the systems of Vauban and Cormontaigne may easily be discovered by an examination of Plate CCXLVI. fig. 3. Vauban makes the faces of his bastions two sevenths of the exterior side, and Cormontaigne one third. Vauban, in his first system, produces the faces of his ravelin to the distance of ten yards upon the face of the bastion from the shoulder, and in his second and third systems, to the distance of twenty yards; but Cormontaigne makes the capital of his ravelins about 120 yards, and produces the faces to the distance of thirty yards from the shoulder; by which means the flanks are better covered, and the bastions and ravelins are enlarged. And this is an advantage; for he is thus enabled to construct a larger redoubt in his ravelin, the curtain and flank are also better covered, and, as the former is shorter, communications are more easily kept up between the bastions. Cormontaigne gives the same breadth to his covered-way as Vauban, but he arranges in a different manner the communication round the extremities of the traverses, as may be seen by inspecting the plate. By this chequer order, or zigzag line of communication, the passage round the extremity of one traverse may be defended by the fire of the other in its rear, or nearer to the body of the place, and the advance of assailants along the covered-way completely checked.

4. *The Modern System.*

The modern system, which is shown in Plate CCXLVII. fig. 2, varies but little from Cormontaigne's. Its perpendicular is one sixth of the exterior side, and the faces of the bastions are one third. The flanks are at right angles with the lines of defence, whereas in Vauban's system they form an angle of about eighty-two degrees; which is not so good, because, in the modern system, the guns placed in the flanks can fire straight along the ditch without being moved or turned on their platforms. The ravelin is formed by setting off thirty-four yards from the shoulder angle of each bastion along the face, which line forms one side of an equilateral triangle, the vertex of which, opposite the centre of the curtain, forms the salient angle of the ravelin. The redoubt of the ravelin is formed by drawing its faces parallel to those of the ravelin from the shoulder angle of the parapet of the bastion; and it has flanks with a ditch about twenty yards in breadth. The *cavalier* in the bastion is drawn parallel to the faces of the bastion, at the distance of forty-eight yards. The ditch on the faces is ten yards in width, but there is no ditch on the flanks. The *coupure*, or cavalier retrenchment, is drawn perpendicular to the faces of the bastions, at thirty-four yards for the counterscarps of the coupures, whilst the scarps are at ten yards, and parallel to these.

5. *Coehorn's System.*

This system, which is shown in Plate CCXLVII. fig. 1, is particularly adapted for the low and swampy country of Holland, where alone it has been practised. It is not, therefore, deemed necessary here to enter into any details respecting it. The great width of the ditch, which is nearly twice as broad as in Vauban's systems, and the narrow space between the flanks, constitute the principal differences between the methods of these celebrated engineers; a difference, as already observed in speaking of Coehorn, caused by the different descriptions of ground on which their respective works were erected.

6. *Outworks.*

Plate CCXLVII. fig. 3, shows several kinds of outworks, as a horn-work *g*, tenaillons *k* and *k*, bonnet *d*, lunettes *a* and *d*, an entrenched bastion *e*, batardeau *f*, and caponnière *h*. These, and other works of a similar description, are constructed for the purpose of occupying some of the ground which might otherwise be of service to the besiegers; but their application must of course depend upon certain localities, and the judgment of the engineer must therefore determine, in each particular place, which is best adapted to the ground, and most proper to be employed with reference to the general defence of the place.

ARMAMENT OF FORTRESSES.

Having thus endeavoured to describe as briefly as possible the principal systems of fortification, it only now remains for us, before quitting this branch of the subject, to say a few words respecting the means of defending a place after it has been fortified. And here we may observe, that it is difficult to lay down any exact rules as to the proportion of ordnance, ammunition, and stores of every kind required for the defence of a fortified place, seeing this must necessarily vary according to the particular situation of each fortress, the system on which its works have been constructed, and the species of attack to which it may be exposed. If, for example, one of the sides be covered by a morass, swamp, or any other obstruction which it is difficult or perhaps impossible to surmount, it must be obvious that, in this case, a smaller proportion of artillery will be required than if the fortress were equally accessible on every side; and, on the other hand, a maritime fortress, accessible at all points, will necessarily require for its defence a larger proportion of ordnance than if it were only assailable on one or a few of these points. Where every front is equally exposed to attack, all must of necessity be equally prepared.

On this subject, however, there have been established certain maxims, of which the following appear to be the most important: First, the proportion of ordnance, ammunition, and stores, should never exceed the quantity necessary for a brave and resolute defence. Secondly, those points which are considered as being most exposed to attack should be most completely armed, whilst the partial armament of the remaining points may suffice. Thirdly, for each of the faces of the bastions which are liable to be attacked, five or six pieces of ordnance should be allotted; for each of the flanks of these bastions, four; for the faces of the ravelins, from five to seven; for the lunettes, when there are such, four pieces of ordnance should be reckoned; besides two or three pieces for each of the places of arms in the covered-way. Supposing, therefore, that one front of a place is to be completely armed, the proportions of ordnance required will be, for the faces of the bastions from ten to twelve pieces, for the two interior flanks from six to eight, for the faces of the ravelins from five to seven, and for five places of arms from ten to fifteen; making the total of ordnance for one front from thirty-one to forty-two pieces. Fourthly, when a place is exposed to attack on two consecutive fronts, the armament of each should be augmented one half; when it is threatened with attack on detached fronts, the armament should, in that case, be doubled. Fifthly, each of the other fronts should merely be provided with such a proportion as to secure it against insult. Lastly, from the foregoing maxims, it appears that a hexagon, having only one front exposed to attack, requires from fifty-eight to sixty-eight pieces of ordnance on such front, whilst in more extensive places, six, eight, or ten pieces should be added for each additional front.

The next consideration is the proportion which the several kinds of ordnance should bear to one another. And here let it be remembered that ordnance of the higher calibres is not the only description which ought to be employed. In many cases medium, and even light guns are more efficacious; for when only troops or working parties are to be fired at, light guns will answer every purpose, as the range of the shot is nearly equal to that of larger guns, and they are of course much more manageable, and may be worked with greater rapidity. But short guns of heavy calibre are best adapted for the flanks; and, generally, the large or heavy ordnance should only be employed to destroy the besiegers' batteries and dismount their guns. The flank guns being only required for the defence of the ditch, short pieces of large calibre, as carronades, which throw a heavy charge of grape or canister shot, are the most proper to be employed. The light guns, as they can easily be withdrawn, should be placed on the covered-way and places of arms, and on outworks of every description. The heavy long guns and mortars, as they are not so easily moved, should be within the body of the place, and as they require a great quantity of ammunition, they should be less frequently used, and only upon urgent occasions. A judicious economy of ammunition is a duty incumbent upon every governor or commandant of a fortified place attacked. The conduct of General Chassé in the defence of the citadel of Antwerp was a model in this respect. From the commencement till the close of the attack, scarcely a single shot was needlessly expended by the garrison.

ATTACK AND DEFENCE OF FORTIFIED PLACES.

Having thus treated of that important branch of fortification which is denominated permanent, and which, being applied solely to the defence of towns, is not liable to be destroyed except by an enemy, we now proceed to consider the attack of fortified places, the general system of which was introduced by Vauban, and so far perfected by that great engineer that it has ever since served as a model for the plans of his successors.

"La résolution des sièges," says the Mareschal, "est une affaire de cabinet. Elle est une suite naturelle de la supériorité que l'on croit avoir sur ses ennemis; mais leur exécution étant une des plus sérieuses, des plus importantes, et des plus difficiles parties, elle demande aussi le plus de mésure et de circonspection." He then goes on to state that the success of sieges depends on several circumstances, such as, "1. Du secret, sans lequel il est difficile de réussir: 2. Des forces que l'on a sur pied pour attaquer les places des ennemis et defendre les siennes: 3. De la disposition des ennemis; car s'ils sont réunis, et aussi forts que nous, ils peuvent nous empêcher d'en faire: 4. De l'état des magazins les plus à portée des lieux sur lesquels on peut entreprendre: 5. De la conjoncture des tems, parce que tous ne sont pas propres aux siéges, et rien n'étant plus ruineux que ceux d'hyver, on les doit eviter tant qu'on peut: 6. Des fonds nécessaires à leurs dépenses; car l'argent est le nerf de la guerre, sans lui on ne sçauroit réussir en rien. Ce sont là des mésures à prendre de longue main, qui doivent être dirigées à loisir; et aprés tout cela, quand on croit les avoir bien prises, souvent tout échappe; car l'ennemi, qui n'est jamais d'accord avec vous, pourra vous interrompre.... Il faut bien peser toutes ces considérations, avant que de se déterminer; et prendre toujours si bien son tems, que l'ennemi ne puisse vous tomber sur les bras avant vos établissemens."[1]

A siege, therefore, being one of the most arduous undertakings in which an army or corps d'armée can be employed; one in which the greatest fatigue, hardships, and personal risk are encountered, and in which the prize can only be won by complete victory; it is obvious that, upon the success or failure of such an enterprise may depend the fate of a campaign, sometimes that of an army, and perhaps even the existence of a state. Of this the failures before Pavia in 1525, before Metz in 1552, before Prague in 1557, before St Jean d'Acre in 1799, and before Burgos in 1812, present instructive examples. By the first, France lost her monarch, the flower of her nobility, and all her Italian conquests; by the second, she was saved from destruction, whilst thirty thousand of her enemies perished; by the third, the greatest warrior of his age, Frederick the Great, was brought to the very brink of destruction; by the fourth, the most successful general of France, and perhaps the greatest commander that any age or country has produced, was stopped short in his career of victory; and by the last, a beaten enemy gained time to recruit his forces, concentrate his scattered corps, and regain that ascendency of which the victory at Salamanca had for a time deprived him. Innumerable other instances of the disastrous consequences usually attendant on the failure of sieges might easily be produced; but those which have just been referred to are sufficient to establish the importance of the undertaking, and to show that the dearest interests of a country may frequently be staked on the sure and speedy reduction of a fortress.

It is therefore of the greatest importance to a state that the sieges undertaken by its armies should be carried on in the best and most efficient manner possible, or, in other words, that by a due combination of science, labour, and force, these operations should be rendered not only short, but certain, and unproductive of any great expenditure of life. But the sieges undertaken by the British have almost never united these three indispensable conditions; and with regard to those which took place during the contest in the Peninsula, it is well known that various defects of organization, and particularly the want of a body of men, such as sappers and miners, trained to the labour required at sieges, not to mention the inexperience of the engineers, and an inadequate supply of matériel, necessitated a departure from all established principles and rules of attack, and consequently led to a waste of life wholly unprecedented in modern sieges. Till late in 1813 the army was unattended by a single sapper or miner: regular approaches were therefore impracticable: it was necessary, in almost every case, to take the bull, as the saying is, by the horns; the last operation of a siege scientifically conducted, namely, battering in breach, was the first, or almost the first, undertaken: and the troops were marched to the assault whilst the defences remained nearly entire, and exposed to every species of destruction which the unreduced means of the besieged could bring to bear against them. The army of a country which has outstripped all others in the useful arts and in mechanical improvements, was left wholly unprovided with those appliances which at once economise labour and life, and serve to render both most effectual for the purposes to which they are applied. But, notwithstanding this great anomaly, which is chargeable against the government alone, and not against either the nation or the army which in the most adverse circumstances so nobly sustained its reputation, it may be observed that, in all periods and in all countries, the means employed for the reduction of fortresses have generally increased and become more overwhelming and irresistible in proportion to the advancement of knowledge and the improvement of the useful arts; and that in Europe during the last two centuries, the extensive diffusion of wealth and knowledge, accompanied by an unprecedented development of talent, all more or less directed towards military movements, has caused the results of sieges, and indeed of almost all the operations of war, to depend much less on individual exertion or casual displays of heroism, than on mere combination and expenditure. This may be made apparent by a slight retrospect of the sieges of the sixteenth century.

At the period here referred to, the art of disposing the several works of a fortress so as to cover each other, and to be covered by their glacis from the view of an enemy, was either unknown or disregarded; whilst the small quantity of artillery in use, its unwieldiness, and the great expense and difficulty of bringing it up, occasioned so little to be used in sieges, that the chief object in fortifying towns was to render them secure against escalade and surprise, by means of lofty walls or altitude of situation. All places fortified prior to the sixteenth century are invariably of this construction. And as the simplicity of the fortresses to be attacked necessarily gave the same character to the operations directed against them, so, in those days, every thing was effected by daring courage, without the aid of science; and gallantly contending in individual combat, or fearlessly confronting danger, were considered as the highest qualities of a besieger. Thus the contest dragged on for months, in petty but sanguinary affairs, and the most persevering or the most hardy troops, however ill organized or supplied, were the most dreaded, and not unfrequently the most successful. But when artillery became more moveable, and large quantities began to be employed in sieges, lofty and exposed walls no longer opposed any adequate barrier; large breaches were speedily effected; places which had formerly resisted for months were carried in a few days; and hence, in order to restore an equality of defence, it became necessary to screen the ramparts from distant fire. The attempt to gain security by concealment rapidly advanced towards perfection, whilst the means of the besiegers remained the same; and between the middle of the sixteenth and commencement of the seventeenth century, works were so skilfully disposed and so well covered, that the defence of towns obtained a temporary superiority over the attack as the latter was then practised. Of this the obstinate and successful defences made by the Dutch against the Spaniards during the reigns of Philip II. and Philip III. may be cited as remarkable examples.[1]

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[1] *De l'Attaque et de la Défense des Places*, pp. 1 and 2. Hague, 1737, 4to.

But unhappily for this pre-eminence, Vauban appeared on the scene, and, supported by Louis XIV., who brought to the attack of fortresses a vast and costly preparation in ordnance, ammunition, and materials, perfected in the early offensive campaigns of that monarch a covered mode of attack, which, by a singular combination of science and labour, and by the steady advances of a few brave men well trained to such work, rendered comparatively easy the reduction of places capable of for ever defying the rude violence of multitudes. These increased means of attack, to which it was found impossible to oppose a successful resistance, caused the art of concealment or covering to be further studied, till at length, in well-constructed fortresses, not a single wall remained exposed to view, and the sap and the mine became as necessary as the gun and the mortar to the success of a besieger. To render this intelligible to the general reader, it may be proper to introduce here a descriptive sketch of the progress of a modern attack, from the excellent work of Sir John Jones, already referred to.

" The first operation of a besieger," says that able and experienced engineer, " is to establish a force able to cope with the garrison of the town to be attacked, at the distance of six or seven hundred yards from its ramparts. This is effected by approaching the place secretly in the night with a body of men, part carrying entrenching tools, and the remainder armed. The former dig a trench in the ground parallel to the fortifications to be attacked, and with the earth that comes out of the trench raise a bank on the side next to the enemy, whilst those with arms remain formed in a recumbent posture, in readiness to protect those at work, should the garrison sally out. During the night this trench and bank are made of sufficient depth and extent to cover from the missiles of the place the number of men requisite to cope with the garrison, and the besiegers remain in the trench during the following day, in despite of the fire or sorties of the besieged. This trench is afterwards progressively widened and deepened, and the bank of earth raised till it forms a covered road, called a parallel, embracing all the fortifications to be attacked; and along this road, guns, waggons, and men securely and conveniently move, equally sheltered from the view and the missiles of the garrison. Batteries of guns and mortars are then constructed on the side of the road next the garrison, to oppose the guns of the town, and in a short time, by superiority of fire, principally arising from situation, silence all those which bear on the works of the attack. After this ascendency is attained, the same species of covered road is, by certain rules of art, carried forward, till it circumvents or passes over all the exterior defences of the place, and touches the main rampart wall at a spot where it has been previously beaten down by the fire of the batteries erected expressly for the purpose in the more advanced parts of the road.

" The besiegers' troops being thus enabled to march in perfect security to the opening or breach in the walls of a town, assault it in strong columns; and being much more numerous than the garrison defending the breach, soon overcome them, and the more easily as they are assisted by a fire of artillery and musketry directed on the garrison from portions of the road only a few yards from the breach; and which fire can, at that distance, be maintained on the defenders of the breach until the very instant of personal contention, without injury to the assailants. The first breach being carried, should the garrison have any inner works, the covered road is by similar rules of art pushed forward through the opening, and advanced batteries are erected in it to overpower the remaining guns of the place; which effected, the road is again pushed forward, and the troops march in security to the assault of breaches made in a similar manner in those interior works, and invariably carry them with little loss." But as it is always an object to preserve the life of even a single soldier, so, when time is abundant, the loss of men attendant on the assault of breaches under these favourable circumstances may be avoided, by pushing up the covered road through the breach, without giving the assault, and thus, by art and labour, the strongest defences frequently fall without any exertion of open force."

From this description it must be obvious that the most important object at a siege is to carry forward the covered road to the walls of the place; that all the other operations are secondary to and in furtherance of such an advance; and that hence the efficiency of armies at sieges depends upon their ability to complete the road at a small expense of life. But in forming this covered road, different degrees of difficulty are experienced in proportion as it advances. At its commencement, the work, owing to the distance from the fortifications, which is usually about six hundred yards, and not being straitened for space, can easily be performed by the common soldiers. But when the road or trench has arrived within a fair range of musketry, or three hundred yards from the place, then particular precautions are required; yet the work at this stage is not so difficult as to prevent its being executed by soldiers who have had a little previous training. At the last stage, when the approaches have been pushed close to the place; when to be seen is to be killed; when mine after mine blows up the head of the road, with every officer and man on the spot; when the space becomes so confined that little or no front of defence can be obtained; and when the enemy's grenadiers sally forth every moment to attack the workmen, and deal out destruction to all less courageous or weaker than themselves; then the work becomes truly hazardous, and can only be performed by selected brave men, called sappers, who have acquired the difficult and dangerous art from which they derive their name. An indispensable auxiliary to the sapper, however, is the miner, who, in the exercise of his art, requires even a greater degree of skill, conduct, and courage than his principal. The duty of a miner at a siege is to accompany the sapper, to listen for and discover the enemy's miner at work, and to prevent his blowing up the head of the road, either by sinking down and meeting him, in which case a subterranean conflict ensues, or by running a gallery close to that of his opponent, and forcing him to desist from working by means of suffocating compositions, and various arts of chicanery, the knowledge of which he has acquired from experience. Without the aid of skilful miners, sappers would be unable to execute that part of the covered road forming the descent into the ditch, not to mention other portions in the formation of which the assistance of the miner is equally indispensable; and without their joint labours and steady cooperation, no besiegers' approaches ever reached the walls of a fortress.

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[1] *Journals of Sieges in Spain*, by Colonel Sir John T. Jones; *Preliminary Observations on the Attack of Fortresses.*

But a siege, though it calls for great personal bravery, unremitting exertion, and extraordinary labour in all employed, yet, if scientifically prosecuted, is alike certain in its progress and its result. More or less skill and exertion in the contending parties may in some degree prolong or abridge its duration; but the sapper and the miner, when skilfully directed and adequately supported, will ultimately surmount every obstacle. On the other hand, sieges undertaken by armies destitute of these auxiliaries, as was that of the Duke of Wellington in Spain, are hazardous in the extreme. Their only chance of success consists in scrutinizing the exterior of a fortress, in order to discover some spot whence, from the irregularity of the ground, or fault of construction, the main escarpe wall may be seen at a distance sufficiently great to enable the ordinary working parties to approach with the covered road, and there to establish batteries for breaching the wall or forming an opening through it into the place. When this is effected, the troops at once advance to the assault of the breach, as in the sixteenth century, thus losing the shelter of the covered road at the moment when the fire of the place becomes most powerful and destructive; and as the fire of the besiegers' distant batteries is necessarily suspended during the assault, in order to avoid killing their own storming party, the garrison can therefore with impunity mount their ramparts and employ every kind of weapon, missile, and instrument in their defence. All the chances are thus in favour of the besieged; for should the columns of attack, under all these disadvantages, arrive in good order at the brink of the ditch, they must descend into it by a wall from fourteen to sixteen feet in depth, which cannot fail to break their order and throw them into confusion; and as no new formation can be attempted in a spot where death is incessantly showering down on them, the assailants rush to the breach more like a rabble than a solid column. From this moment success hinges on the individual and confident bravery of the officers and troops, and the unshrinking firmness of the general commanding, in at once encouraging and supporting their efforts. But although these qualities, when united in a high degree, may, at a great sacrifice of life, enable the assailants to overcome all resistance, yet an assault of this nature, attempted under ordinary circumstances and feelings, has almost invariably proved unsuccessful. Indeed it may be laid down as the general result of experience, that should an army unprovided with sappers and miners, and the necessary materials and means to render their services efficient, be opposed to a place fortified according to the modern system, with its walls completely covered, all the usual methods to reduce it would prove unavailing; no period of time nor sacrifice of men would be sufficient to purchase success, and the prudent course would be to decline an attempt pregnant with hazard, perhaps ruin.[1]

Having thus given a general description of the methods of attack, we shall now subjoin, on high authority, a view of what is considered as necessary for the proper defence of fortified places. An order issued by the French minister of war in 1813 contains directions on the subject which are almost universally applicable, and therefore deserve a place here. Every commander is directed to consider his garrison as liable to be unexpectedly attacked, and to pass at once from a state of peace into one of war or siege, either by rebellion, by unlawful assemblies, by the presence of an enemy, by surprise, or by sudden assault; in a word, by unforeseen causes, of which the history of war offers numerous examples. He is therefore ordered, even in time of peace, to fix his plan and arrangement for defence, according to such supposed attacks as may appear most probable, and to determine, for the principal cases which may be likely to occur, the necessary posts, reserves, and movements of the troops, and to take measures to ensure the due and active cooperation of every corps of the garrison. He ought, particularly, to make himself thoroughly acquainted with, *first*, the ground beyond the place which may be within the circle of action, of investment, and of attack; *secondly*, the fortifications of the place, its interior, its buildings, its military edifices or establishments; *thirdly*, the garrison, the means of the place in artillery, in ammunition, and in other stores of every kind; *fourthly*, the population to be subsisted in time of siege, the men capable of bearing arms, the master and journeymen artificers fit to be employed either on the works or in case of fire; and, *fifthly*, the provisions, materials, tools, and other resources which the town itself and surrounding country can furnish, and which it might be necessary to secure in case of siege. In order to enable governors and commanders to comply with these instructions, which are equally clear and precise, the minister proceeds to detail their principal duties, according to the circumstances in which they may find themselves placed; but for these we must refer to the general order itself, which is a masterpiece of its kind, and in all probability emanated directly from Napoleon himself. Its object appears to have been to produce a belief, that by taking proper precautions, and making a full use of means previously provided, the defence might be rendered equal, if not superior, to the attack; and although it is acknowledged on all hands that the idea of attaining such an advantage for the defence is, generally speaking, fallacious, yet the importance of the directions embodied in the order is not on that account diminished, and where they are duly observed, the nature and extent of the resistance must be materially increased.

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[1] *Journals of the Sieges in Spain*, Preliminary Observations.—"These considerations," says Sir John Jones, to whom we are indebted for the above account of the various modes of attacking fortified places, "have for many years had their due weight with the great powers of Europe, and induced them to form and keep up, as integral portions of their military strength, every necessary auxiliary for the reduction of fortresses; and their sieges have in consequence become certain and comparatively bloodless. But England, constitutionally jealous of permanent military establishments, always discountenanced military organization and military preparation till the hour of need; and with respect to sieges, they being of rare occurrence, and moreover exclusively offensive operations, even carried her jealous feelings beyond the bounds of rational prudence; for, possessing a corps of officers professionally educated and well grounded in the science of attack and defence, she denied them every requisite establishment to render their acquirements availing, and most unreasonably expected her armies to reduce the skilfully fortified and well-covered places of the nineteenth century with means inferior to those brought against the exposed and ill-constructed places of the sixteenth and seventeenth centuries." And what was the immediate consequence of this irrational jealousy and niggardly parsimony? Contrary to all ordinary calculation, the fortresses garrisoned by the French in Spain were reduced; but at what a prodigious expenditure of life was this effected? In the several attacks upon Badajoz, two of which, from extrinsic circumstances, proved abortive, a little army was sacrificed; as many men, in short, as would have been sufficient for the consumption of *ten* sieges undertaken with adequate means, and conducted according to the ordinary rules of science. But this is not to be understood as involving any reflection against the military talents of the general or the professional ability of the engineers. General Foy, in his work on the war in the Peninsula, has indeed made such a charge, condemning the mode of attacking fortresses adopted by the British in Spain as unskilful and inefficacious, and bringing it forward as indisputable proof of the low state of military knowledge in our army. But it should be recollected that the adoption of this mode was not a matter of choice, but of necessity; and that if it was in its own nature rash, hazardous, and inefficient, the fact of its having been directed against Ciudad Rodrigo and Badajoz with such rapidity of development and certainty of result as to outstrip the calculations of the French marshals, deceive the vigilance of French governors, paralyse the science of the French engineers, and baffle every defensive effort of the French garrisons, is surely no evidence of deficiency in military talent and professional skill. The objections to this mode of attack are insurmountable and decisive; that it succeeded in the instances referred to is merely a proof what British soldiers, even when acting under the greatest disadvantages, are capable of accomplishing.

Attack of the Citadel of Antwerp.

For the elucidation of the principles above stated, we now proceed to give a sketch of the attack on the citadel of Antwerp; first, because this was the most regular and scientific siege which had taken place for many years; and, secondly, because, as a practical operation, an account of it must not only be more interesting, but at the same time more instructive, than any description whatsoever of the formal theoretical plans which are usually drawn in the military schools.

The French army employed to cover and conduct the attack of the citadel of Antwerp, in November and December 1832, was placed under the command of Marshal Gerard, and amounted to 54,000 infantry, 6000 cavalry, and 6450 engineers, artillery, and pontonniers, making a total of 66,450 men, and 14,300 horses, with 144 pieces of siege and 78 of field artillery. On the 24th of November Marshal Gerard established his head-quarters at the village of Berchem, about 2500 yards from the citadel, and issued orders to commence operations in the evening as soon as it became dark. The garrison of the citadel, under General Baron Chassé, amounted to 4470 men, with 144 pieces of ordnance of all calibres, and abundance of ammunition and stores.

At eight o'clock P. M. on the 29th November the French troops destined for this service consisted of 18 battalions, 900 artillery, and 400 sappers, in all about 17,140 men, assembled at the depôts of intrenching tools. The flank companies of these brigades, supported by twelve eight-pounders and a strong piquet of cavalry, formed the covering party under the direction of General Haxo, by whom and the officers of his department (the engineers) the first parallel and approaches were traced out, whilst General Niègre and the officers of artillery marked the sites of the projected batteries. The first parallel leaned on the covered-way of the right face of Montebello, and extended towards Kiel, its nearest point being about 325, and its farthest 435 yards from the advanced front of the citadel. The distance covered by the first parallel, from right to left, was 1870 yards, and that by the approaches 3750 yards. The communications from the right and centre debouched from the Malines Chaussée, in the village of Berchem, parallel to the road leading from that village to the Harmony and St Laurent; that from the left commenced near to the garden called Heinrich's; whilst a fourth, on the extreme right, sprung from the covered-way of the left flank of Montebello, opposite to the first traverse.

On the second night, from 30th November to 1st December, five approaches were pushed on in front of the first parallel; two in the direction of the capital of the Toledo bastion, two upon that of the Lunette St Laurent, and one, being the fifth, terminating in a place of arms on the extreme left. From the 1st to the 2d December two zigzags were added to the approaches; one from the centre, in the direction of the gorge of St Laurent, and the other on the right, diverging towards the curtain, between the Toledo and Fernando bastions. The badness of the weather sadly incommoded the workmen, and prevented the artillery getting the guns into battery. Between the 2d and 3d December four zigzags were made in front of the approaches on the right and centre, and half a parallel was formed to complete the place of arms constructed on the left during the night of the 30th November. The heads of the zigzags were pushed to within 135 yards of the glacis. The batteries Nos. 1, 2, 3, 4, 5, 6, and 9, with two for mortars in the rear, were armed, and ready to be unmasked at a moment's notice. The arming of Nos. 7, 8, and 10, on the extreme left, was impeded by the difficulties of the ground. From the 3d to the 4th December, the second parallel was traced and commenced, its right leaning on the foot of the glacis of the counterguard, its centre and right 130 yards distant from the place of arms in the covered-way of the Toledo bastion, and its left towards the right of the covered-way of St Laurent, at 90 yards from the crest, and 15 from the foot of its glacis. The length of the second parallel was 1250 yards, and, together with its approaches from the first parallel, it occupied 3025 yards of ground. By the greatest exertions batteries Nos. 7, 8, and 10 were armed during the night. This completed the armament, and, at 11 A. M. on the 4th, the embrazures were unmasked, and the signal being given, the batteries opened their fire from centre to flanks, and maintained it steadily during the day.

From the 4th to the 5th of December an approach was pushed on from the second parallel, almost in a direct line upon the salient angle of St Laurent, and an entry was made into the covered-way by a return to the left. The garrison discovered this, and opened a sharp fire from the Lunette; a lodgment was, however, effected near the spot usually occupied by the first traverse. At this time the garrison suffered much from the fire of the besiegers. From the 5th to the 6th the lodgment made the previous night in the covered-way of the salient place of arms of St Laurent was prolonged as far as the first traverse. But the besieged kept up so vigorous a fire that the French engineers were obliged to renounce the flying and adopt the full sap. The zigzag in the counterguard, being about three feet in width and four in depth, was conducted along the parapet, nearly to the extremity of the right flank, and within 180 yards of the counterscarp of bastions Toledo and Fernando; and two lodgments, blinded with fascines, were made in the parapet for six rampart guns to enfilade the covered-way of the Toledo bastion. In the mean time a steady fire was kept against Kiel, the ravelin in its rear, and the Paciotto bastion. From the 6th to the 7th a battery of 24-pounders near the village of Burcht on the left and Hoboken on the right opened on the gunboats which flanked the French post at the Melk Huys. It was intended to assault St Laurent this evening; but as the lunette was found to be too well protected by *trous-de-loup*, the project of storm was abandoned, and the regular method of descent, passage, and mine, determined on.

Between the 7th and 8th of December a shell penetrated the blindage of the laboratory, and setting fire to loaded bombs and other combustibles, caused considerable havoc. A battery for six mortars, E, on the right between Nos. 3 and 4, now opened its fire; another, F, also for six mortars, was traced behind the centre of the parallel; and platforms for four mortars were laid down near Montebello. The fire of these batteries was directed on the Toledo bastion and the buildings within it. On the previous day jets of smoke and flame were seen to issue from the Great Barracks, and, in spite of every exertion on the part of the garrison, the whole building soon became involved in a general conflagration, which raged with such fury that by the evening of the 8th it was entirely consumed.

From the 9th to the 10th of December the operations against St Laurent were renewed with great activity, and the sap advanced to the crotchet of the second traverse, whilst that intended to debouch upon it from its right was likewise pushed on. The principal operation of the night, however, was the opening of the third parallel, 130 yards in advance of the second, its right debouching beyond the Boom Chaussée, from the branch running into the covered-way of the counterguard, and its left uniting with the boyau parallel to the foot of the glacis of St Laurent. At this time the garrison suffered much from the vertical fire of the mortars and howitzers, especially the great mortar, and the new-model eight-inch howitzers. Until the year 1822, the eight-inch howitzer in common use in France measured three feet six inches French, and weighed 1096 lbs., or twenty-three times the weight of the loaded projectile, whilst its calibre was equal to a solid shot of 80 lbs., and contained 65 ounces of powder. The new-model howitzer is an improvement on the Russian licorne and the Spanish heavy howitzer, perfected by Colonel Paixhans. The raft for the blinded descent into the ditch was brought up to the lodgment, and a second descent *à ciel couvert* was commenced to the left of the first. The third parallel was, at the same time, improved and widened. A little after dusk on the 10th the besieged made a sortie, which was driven in, but not until damage enough had been done to occupy the French all the night of the 10th and morning of the 11th in repairing it. From the 11th to the 12th three rafts were got ready, and placed in the descents to the ditch; they were about twelve feet by eight. At dusk the miners returned to the escarpe, and, in an excavation made the previous night, fixed two petards, which, by their explosion, produced a fissure in the wall; and a serjeant having immediately entered the hole, commenced a gallery under the centre of one of the arches. At 11 A. M. on the 12th the battery mortars, H, on the extreme right of the second parallel, opened their fire, which, combined with that from the others, told severely on the Toledo bastion. The miners still continued their work under the Lunette St Laurent, and commenced chambers for three mines. The fourth parallel was widened during the day.

Between the 12th and 13th of December the miners were at work in the chambers under St Laurent, which were not yet completed. On the right the covered way of the left face of the Toledo bastion was crowned to within sixty-five yards. From the 13th to the 14th, after nearly sixteen nights of open trenches, the arrangements for the assault of St Laurent were completed, and orders were issued to prepare for the storm. Much, a great deal too much, was said of this out-work, defended by little more than a hundred men, one five-and-a-half inch howitzer, two coehorn mortars, and a six-pounder. The mine being reported charged, the blinded descent into the ditch was pierced as soon as it became dark, and every thing got ready for the assault. Three storming parties, consisting of the flank companies of the 65th regiment of the line, were posted in readiness, with a column of reserve; and at 5 A. M. on the 14th, every preparation being completed, the match was applied to the saucissons of the mines. After a few moments of suspense, three successive explosions took place, and the escarpe immediately presented a wide and practicable breach. The fascines for crossing the ditch had been injured by the explosions; but after a little delay the storming party entered almost without opposition, and made prisoners one lieutenant and forty-eight rank and file, the others having escaped into the citadel. Thus fell the Lunette St Laurent.

After this, operations were carried on against the citadel, and at 11 A. M. of the 21st December the battering in breach commenced, and continued for two days. At length, on the 23d, when a practicable breach had been formed, and Marshal Gerard was about to deliver the assault, the garrison surrendered, after as gallant a defence as any recorded in military history, though more remarkable for its passive than its active character. When Marshal Gerard, accompanied by the French princes, entered the fortress, they found General Chassé in a casemate in the Alba bastion, which he had occupied during the siege. On their progress from the gate to the governor's quarters, they passed through a scene of desolation and ruin, intermixed with painful and disgusting objects, which baffles all description. The whole, indeed, presented an unparalleled chaos of black and smouldering destruction; and, with the exception of the principal powder magazine, two or three service magazines, and the hospital, not a building was standing. The terrepleins of the bastions were ploughed into deep ruts by the shells; the gorges were encumbered with heaps of fallen rubbish; and though the casemates and subterranean communications were not perforated, all of them had sustained damage from the incessant explosion of shells, and they emitted an offensive, nay, almost insupportable odour, caused by the number of men who had been crowded into these vaults. Every thing was of course said by the victors to console and flatter the vanquished. When Count Gerard took his leave of General Chassé, he observed to the brave veteran, "that it was high time to surrender; that he had gallantly and honourably done his duty, and that he ought not to have held out a day longer." With a fortress reduced to a heap of ruins, a garrison exhausted and extenuated, and a breach sufficiently wide to admit a column formed upon a front of a hundred, it would not have been bravery, but madness, to attempt, under such circumstances, to stand an assault.

This operation, so instructive in a military point of view, is also remarkable as having occurred in a time of general peace. It would be out of place here to enter into any detail of the complicated series of events and negotiations out of which so singular an occurrence arose: we shall therefore content ourselves with observing, generally, that Great Britain and France, as joint guarantees for the integrity and independence of Belgium, having failed in every attempt to procure the evacuation of Antwerp by means of negotiation, were obliged, by the faith of treaties, to have recourse to force. Hence the siege, politically considered, is to be viewed merely as an ejectment executed against the king of Holland, who had refused to renounce possession, unless compelled to do so.[1]

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[1] The account of the siege given above is abridged from that published in the *United Service Journal*, and which is decidedly the best that has yet appeared

The following is a list of the different batteries, with the direction of their fire respectively:—

	Number of Batteries.	Twenty-four Pounders.	Sixteen Pounders.	Eight-inch Howitzers.	Ten-inch Mortars.	Distance in Yards.	Direction of Fire.
	1	6	...	2	...	535 and 550	Battering the left face of Toledo, and gorge of St Laurent.
Opened on the 4th and 5th December.	2	...	2	2	...	500	Ricochetting the left face of Toledo.
	3	4	...	2	...	640	Battering the left face of the Ravelin.
	4	...	3	2	...	650	Ricochetting left face of the Ravelin.
	5	6	2	1	...	680 and 430	Battering right face of Toledo, and ricochetting left of Toledo.
	6	...	2	2	...	700	Ricochetting left face of Toledo.
	7	6	2	1	...	380 and 700	Ricochetting left face of St Laurent, and battering right face of Paciotto
	8	...	3	2	...	465	Ricochetting left face of Ravelin.
	9	...	...	6	...	820	Battering salient angle of Paciotto.
	10	8	...	...	...	650 and 520	Battering left face of Ravelin, and Lunette of Kiel.
	A	...	...	...	10	850	Not armed.
	B	...	...	...	9	1000	Body of the Citadel.
	C	...	...	..	11	1050	....
	D	...	...	...	10	850	....
	...	30	14	20	40	......	....
	11	4	...	...	...	500	Battering the right face of Toledo.
Between the 8th and 18th.	12	...	3	...	...	435	Battering the Batardeau.
	13	...	4	...	...	220 and 275	Battering the left face of Ravelin.
	E	...	...	...	6	500	The body of the Citadel.
	F	...	...	...	6	490	....
	G	...	...	...	6	650	....
	H	...	...	...	6	380	....
	K	...	...	...	8	600	....
	14	6	...	...	...	50	Breaching Battery.
	15	6	...	...	...	350	Counter-battery against the left flank of Fernando.
	16	...	...	...	...	125	Six pierriers on the Ravelin and Toledo.
	L	...	...	...	10	250	Terreplein and rampart of Toledo.

The French brought against this place 66,450 men, 14,300 horses, and 222 guns of all descriptions; and they lost during the siege 108 killed, and 695 wounded, total put *hors de combat* 803. The Dutch had 4937 men in the garrison, of whom they lost 122 killed, 369 wounded, and 70 missing, total 561.

Siege of Dantzick.

Having thus given an example of an interior and passive defence, we shall now, in further illustration of the principles already laid down, advert to one of a different if not opposite kind. The siege of Dantzick, whether considered with reference to the magnitude of the operation, the difficulties to be surmounted by the besiegers, or the active and varied character of the defence, was certainly one of the most memorable events in the campaign of 1807. Before the war of 1806 and 1807, the fortifications had been much neglected, because, from the position of the place, no one suspected that it would have to sustain a siege. But when the battles of Iena and Auerstadt had entailed destruction on the Prussian army, and laid open the kingdom, General Manstein, who commanded at Dantzick in the absence of Field-marshal Kalkreuth, the titular governor, had laboured with much activity in improving the exterior works, and particularly in causing them to be strongly palisaded. It is necessary, therefore, to describe the principal defences at the period when the place was invested by Marshal Lefebvre, at the head of the tenth corps of the Grand Army, and immediately before the commencement of the trenches on the 1st of April 1807.

The city of Dantzick, traversed by the Moltau, was surrounded with large ditches filled by that river, the waters of which, retained by several sluices, formed, to the eastward, a vast inundation, which, reaching on one side to the suburbs of Ohra and St Halbrecht, and on the other to the dikes of the Vistula, extended about four leagues, and covered two thirds of the eastern fronts. On the north, the Vistula runs about two hundred and sixty yards from the covered-way, leaving a space between the left bank and the glacis of the place, consisting of an impracticable marsh, intersected by some canals; and at its embouchure, distant nearly three miles, the banks were defended on the right by the fort of Weichselmunde, and on the left by an intrenched camp in the small island of Neufahrwasser, intended to cover and protect the arrival of such succours as might come from the seaward. The ground adjoining the banks of the Vistula being intersected by canals and covered with marshes, was extremely unfavourable to a besieger, as it rendered it difficult for him to form establishments or raise works of proper solidity, and forced him to extend his quarters, disseminate his troops, and multiply his posts. At the period in question, this inconvenience was the more severely felt, because the besieging force was inferior in numbers to that of the garrison, and it required the most vigilant caution to occupy numerous posts without unduly weakening it. The communication between the place and the fort of Weichselmunde was maintained by a series of redoubts constructed on the borders of the Vistula, and particularly by the advantageous position of the isle of Holm, which enabled the besieged so to approximate the fire of the place to that of the fort as only to leave between them an interval of about fourteen hundred yards, and also to communicate with Weichselmunde by the canal of Laack, in spite of batteries which the besiegers might establish at Schellmühl. The French, therefore, could not attempt to throw a bridge over this part of the Vistula until they had made themselves masters of the isle of Holm. On the west, two chains of hills, separated by the valley of Schidlitz, covered this part of the enceinte; and the prolongations of these hills were crowned by two forts, that of Bischopsberg and that of Hagelsberg, which, being connected by continuous intrenchments, formed a second enceinte, flanked upon one side by the inundation of the Moltau, and upon the other by the left bank of the Vistula. This new enceinte, though constructed of earth, and without revêtement, was nevertheless secure against insult; and as the covered-way, as well as the foot of the scarps and counterscarps, bristled with strong fraises, which served instead of revêtements, the besiegers had no hope of succeeding by a coup-de-main, and were therefore obliged to proceed by a regular attack.

From this description of the defences of Dantzick, it is easy to perceive that the difficulties attending the operation must have been very great. The principal of these, as stated by General Kirgener,[1] who, until the arrival of General Chasseloup, directed the attack, were, 1*st*, that Marshal Lefebvre had at first an army inferior to that of Marshal Kalkreuth, and that this army was in a great measure composed of new troops, all those destined for the siege not having then arrived; 2*dly*, that, owing to the badness of the roads and the inclemency of the season, the artillery experienced the greatest difficulty in bringing up its convoys, whilst the establishment of the batteries was retarded, and a scarcity of ammunition sometimes prevailed; 3*dly*, that the place requiring an immense circumvallation, which, in fact, could not be completed until after the arrival of reinforcements, the corps of troops which occupied the quarters were extremely weak, and hence could neither furnish a sufficient number of workmen at a time, nor even the number of men necessary for guarding the trenches; and, 4*thly*, that the besiegers had no good plan of the place, no idea of the depth of the ditches, and that, as the accidents of ground in front of the fortifications were extremely diversified, they could only be reconnoitred in proportion as the works advanced. These circumstances, the necessity of concentrating the greater part of the troops close to the camp of Neufahrwasser, by which succours arriving by sea might debouch, and, lastly, the advantage which the besieged had been able to preserve of remaining masters of part of the suburbs, determined the chief engineer, after the investment had been effected, to direct the principal attack against the Hagelsberg, and a false one against the Bischopsberg fort. The true point of attack was the long branch of lines in the plain connected with the bastion on the right of the Hagelsberg; "c'était là le défaut de la cuirasse;" but, for the reasons above stated, General Kirgener was induced to direct his approaches against the fort itself.

As the details of this great siege would fill a considerable volume, all that our limits permit us to attempt is merely to indicate the principal occurrences. On the 1st of February 1807 the troops of General Dombrowski began to approach Dantzick, and took up a position at Mewe, upon the left bank of the Vistula. On the 15th General Ménard, commanding the Baden contingent, arrived at the same point, and repulsed a detachment of the garrison of Dantzick, which had advanced from Dirschau to attack him. On the 23d General Dombrowski, having been reinforced, received orders to attack a large detachment of the enemy which occupied an advantageous position at Dirschau and its environs. The combat here was obstinate and sanguinary; but the Prussians, though intrenched in a church and a churchyard, were dislodged and driven back, chiefly by the Poles, who, exasperated by their long resistance, put to death without mercy all who fell into their hands. After the combat of Dirschau, General Manstein no longer sought to obstruct the distant approaches. The troops destined to form the besieging army now arrived in succession, and the parc of artillery began to be formed. On the 12th of March Marshal Lefebvre found himself in a condition to close in on the place; and the troops of the garrison having withdrawn, he distributed his own in the following positions: A battalion of French light infantry at Ohra, a Saxon battalion at St Halbrecht in the Burgerfeld, and two others at Tiefensee and Kemlade; the Poles occupied Schonfeld, Kowald, and Zunkendin; some battalions took post at Wonnenberg, Neukau, Schudelkau, and Sniekau; the Saxon cuirassiers and light horse were stationed at St Halbrecht and Guirsehkens; the 19th regiment of French chasseurs at Burgfeld, and the 23d at Schudelkau; the Baden dragoons and hussars at Wonnenberg, and the Polish lancers at Langenfurt. On the 16th the marshal attacked the village of Stolzenberg, which he carried after a warm resistance, as he did also the suburb of Schidlitz to which the Prussians had retired; and on the 18th the place was entirely invested, with the exception of the eastern part, which, by the isle of Nehrung, communicated with Königsberg. Field-marshal Kalkreuth now arrived in Dantzick, and assumed the command of the place. The next operation of the besiegers was the attack of the isle of Nehrung, which, after a severe and protracted struggle, was carried in the most gallant manner, and measures immediately taken to secure possession of this important conquest. A bridge was also established on the Vistula, and various works constructed to check the attempts of the enemy either on the side of Dantzick or on that of Pillau. At this time the governor, who, besides the burgher militia, had under his command a garrison of 18,000 men, made a sortie for the purpose of destroying the works already commenced by the besiegers; but the attempt failed, and the Prussian columns were compelled to retreat into the place without having obtained the smallest success upon any point.

As it had been decided that the principal attack should be directed against the fort of Hagelsberg, favoured by two false attacks, the one directed against the intrenched camp at Neufahrwasser, and the other against Bischopsberg, and also by two other secondary attacks on the left bank of the river, ground was broken on the night of the 1st and 2d April, at the distance of sixteen hundred yards from the palisades. The approaches were pushed forward with the greatest vigour, and on the night of the 11th the second parallel was commenced by means of the flying sap. On the morning of the 12th the marshal ordered the batteries to be armed, which was accordingly done.

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[1] This officer, the head of the engineer staff, and one of the most distinguished in that branch of the service, fell in the field of battle at Bautzen, where he received his death-wound from the same ball which killed Duroc, the grand marshal of the palace, and the intimate friend of Napoleon.

On the 13th the enemy made a sortie in force, attacked the Saxons with great impetuosity, carried a redoubt constructed upon the mamelon of Hagelsberg, and even penetrated to the head of the trenches; but they were ultimately repulsed, though not without difficulty and loss. By the 23d all the batteries of the first and second parallels, and those of Stolzenberg, were armed, and emplacements were provided for field howitzers, in order to throw shells into all quarters of the city. At daybreak on the 24th the batteries were unmasked, and though the garrison returned the fire with the greatest vivacity, that of the besiegers soon obtained the ascendency, committing great ravages in the place. Being apprised of this circumstance, Marshal Lefebvre summoned the governor, who replied in a manner worthy of himself. The fire of the mortar and reverse batteries continued during the 25th, in the course of which a new battery was constructed between the low flanks of the Stolzenberg; and the direction of some others changed, in order to batter the right bastion of Bischopsberg, the fire of which had greatly incommoded the French batteries. During the day of the 26th, the fire on both sides was exceedingly animated; but at seven in the evening, that of the garrison suddenly ceased, and a column of six hundred Prussian grenadiers, followed by two hundred workmen, soon afterwards sallied out of the place. As the sortie had been foreseen, however, preparations were made to repulse it, which was done by a combined attack in front and on both flanks, in consequence of which the whole column was either killed or taken. Meanwhile the works were vigorously pushed forward at all points. The batteries of Stolzenberg were united with the attack on the Bischopsberg; emplacements were prepared for batteries *à ricochet;* at the attack of the Lower Vistula the works were continued, and a tongue of land situated at the extremity of the isle of Holm taken possession of and isolated by means of a cut; whilst at the principal attack the greatest exertions were made to prolong the right of the third parallel, and enlarge the communications. On the 30th April the batteries of the besiegers, augmented by several pieces which had arrived from Warsaw, thundered on the place, in different quarters of which conflagrations now appeared; and the besieged replied by the fire of all the batteries of the front of the attack, directing more than thirty pieces on a redoubt, which fired with the greatest effect. But as the fire of the besiegers had made little impression on the exterior fortifications, which were of earth, it was during the first days of May directed chiefly against the palisades, in order to facilitate the assault of the place; and the utmost activity was at the same time evinced in extending, improving, and urging forward the attack; whilst, on the other hand, the garrison showed equal vigour in obstructing the approaches and destroying the works of the besiegers. In fact, notwithstanding the address of the French artillery, that of the garrison still remained effective, because it had not been possible to ricochet the lines of the fortifications, and the resources of the besieged in munitions of all kinds were more considerable than those of the besiegers.

On the urgent recommendation of General Chasseloup, who had by this time assumed the direction of the attack, it was now decided that the isle of Holm should be assaulted, as the possession of it would enable the besiegers to construct new batteries, to take in reverse the front of the attack. The besieged had spared no pains for the preservation of this important post. In the night of the 6th and 7th of May, however, it was attacked, and, after a desperate resistance, carried; whilst the possession of it was secured by works added to the intrenchments which had just been stormed, and the batteries were turned against the place. At the principal attack the fire of the besiegers had also mastered that of the besieged; and Marshal Lefebvre was preparing to assault the fort of Hagelsberg, when a Russian corps d'armée under the command of General Kamenskoi arrived by sea, and disembarked at the intrenched camp of Neufahrwasser.

At the moment of landing his troops, General Kamenskoi was ignorant of the capture of the isle of Holm, and he was disconcerted to find such an obstacle to his communications with the place. This occasioned delay, which proved fatal to his enterprise; for had he attacked immediately on landing, it is not improbable that he would have succeeded. It was only on the 15th of May, however, being the fourth day after the disembarkation, that he resolved to make an attempt to succour the besieged city. He began to debouch at four in the morning, and, under cover of a brisk cannonade, formed his force, consisting of from eleven to twelve thousand men, in four columns of attack. The onset was impetuous, and at first the Russians gained ground, thrice attempting to penetrate the French line; but they were ultimately repulsed at all points, and forced to retreat with great loss to the intrenched camp. Field-marshal Kalkreuth made no attempt to second this attack by means of a general sortie, which would have placed the French between two fires; and by its failure the fate of Dantzick was decided. Such was the issue of the only effort made by the allies to relieve this important fortress.

The works of the besiegers were now pushed forward with redoubled vigour; and in the course of the following day preparations were made for the assault of Hagelsberg. Foreseeing this, Marshal Kalkreuth resolved to make a last effort to destroy the nearest works of the besiegers, and for this purpose ordered a grand sortie, which took place on the evening of the 20th May; but although the Prussians fought with all the fury of despair, they were at length driven back, and pursued even into the ditch of the place. On the 21st the army of siege was reinforced by the arrival of the troops of Marshal Mortier, part of which had remained before Colberg; the marshal himself quickly followed; and orders were immediately issued for the assault of Hagelsberg. Before giving the signal, however, Marshal Lefebvre again summoned the governor of Dantzick, who, having no longer any hope of being succoured, and convinced that the besiegers were in a condition to make themselves masters of the fort of Hagelsberg, showed a disposition to capitulate. A suspension of arms was accordingly agreed to, and this was followed, on the 24th of May, by a capitulation, the principal conditions of which were similar to those which the field-marshal himself had granted to the garrison of Mayence in 1793.[1]

FIELD FORTIFICATION.

Field fortification is the art of constructing all kinds of temporary works in the field. An army intrenched, or fortified, in the field, produces, in many respects, the same effect as a fortress; for it covers a country, supplies the want of numbers, stops the advance of a superior enemy, or, if he chooses to risk a battle, obliges him to engage at a disadvantage. "In a war of march and manœuvre," says Napoleon, "if you would avoid a battle with a superior army, it is necessary to intrench every night, and to occupy a good defensive position. Those natural positions which are ordinarily met with are not sufficient to protect an army against superior numbers without recourse to art. Those who proscribe lines of circumvallation, and all the assistance which the science of the engineer can afford, deprive themselves gratuitously of an auxiliary which is never injurious, almost always useful, and often indispensable. It must be admitted at the same time that the principles of field fortification require improvement. This important branch of the art of war has made no progress since the times of the ancients. It is even inferior to what it was two thousand years ago. Engineer officers should be encouraged in bringing this art to perfection, and in placing it on a level with the rest."[1]

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[1] Dumas, *Précis des Evenemens Militaires*, tom. xviii. chap. 19, p. 123. *Relation authentique du Siege de Dantzick.* "Les principales conditions de la capitulation furent que la garnison sortirait avec armes et bagages, drapeaux déployés, tambour battant, mèche allumée, avec deux pièces d'artillerie legère et leur caissons attelés de six chevaux, pour être conduite aux avant-postes de l'armée Prussienne à Pillau, en passant par l'île de Nehrung, et en cinq jours de marche. Cette garnison s'engageait à ne pas servir contre l'armée Française pendant un an." (Dumas, *ubi supra.*)

Whenever Napoleon had time and occasion for strengthening his position by field-works, he acted upon the principles recommended in the above extract, as almost all his predecessors had done. In the wars which followed the revolution of 1688, in those of Queen Anne's reign, and during the Seven Years' War, we find the commanders of each period, William III. the Duke of Marlborough, Marshal Villars, Marshal Saxe, Frederick II. and Marshal Daun, practically exemplifying their conviction of the great utility of field-works. A few redoubts saved Peter the Great at Pultowa, and enabled him to gain a decisive victory over his formidable antagonist; and at Borodino, some slight open field-works, thrown up by the Russians, caused the French great loss, and rendered too costly to be of almost any avail the victory which, by incredible efforts of gallantry, they gained. It has been argued by some, against intrenchments and field-works, that they have oftener been carried than successfully defended, and that hence incommensurate importance has been attached to them. But it should be remembered, on the other hand, that victory in such circumstances has generally been purchased at an expense which rendered it in effect equivalent to defeat; and that a practice which the greatest commanders of ancient and modern times have approved and followed, cannot be one of doubtful utility. At Austerlitz, where the contending armies were nearly equal, Napoleon was preparing to superintend the construction of intrenchments when he found himself called upon to receive battle; and in Portugal, the Duke of Wellington showed to what importance the art of the engineer might be turned for influencing, not merely the fortune of a campaign, but the fate of a cause. The lines of Torres Vedras, which formed the *ne plus ultra* of the powerful French army under Massena, and from which the tide of war was rolled back broken into Spain, were perhaps the most remarkable works of the kind ever constructed.

"Lisbon," says Sir John Jones, "being situated at the extremity of a peninsula formed by the sea and the Tagus, it is plain that if an army be so posted as to extend across the peninsula, no enemy can penetrate into the city without a direct attack on the army so formed. It was on this principle that the lines covering Lisbon were planned by Lord Wellington. Nature drew the rude outline of a strong defensive position, and art rendered it perfect. A tract of country thirty miles, extending from the mouth of the Zizandra on the ocean, to Alhandra on the Tagus, was modelled into a field of battle; mountains were scarped perpendicularly, rivers dammed, and inundations formed; all roads favourable to the enemy were destroyed, and others made to facilitate the communications of the defenders; formidable works were erected to strengthen and support the weak parts, whilst numerous cannon places, on inaccessible points, commanded the different approaches to them, and gave an equality of defence to the whole position."[2] These lines were not continuous and connected works; they consisted of independent forts, redoubts, flêches, redans, batteries, &c. so placed as to command and enfilade every approach, and to support each other by a cross or a flanking fire. The first line occupied a front of twenty-nine miles between the sea and the Tagus; and by means of telegraphs intelligence could be conveyed from one extremity to the other in a few minutes; whilst the troops were disposed in masses in the rear of the works, ready to move upon any point that might be attacked, by interior communications shorter than any by which the enemy could advance. "The aim and scope of these works," says Colonel Napier, "was to bar the passes, and to strengthen the fighting positions between them, without impeding the movements of the army. These objects were attained; and it is certain that the loss of the first line would not have been injurious, save in reputation, because the retreat was secure upon the second and stronger line, and the guns of the first were all of inferior calibre, mounted on common truck carriages, and consequently immovable and useless to the enemy."[3] Both lines occupied a front of fifty miles, on which there were erected one hundred and fifty forts, mounting in all about six hundred pieces of artillery.

Before this formidable position, defended by a double line of works, and by an army massed and ready to move upon any point by interior communications, the French remained five months, wasting their numbers and resources; until at length, finding it utterly impracticable to force any part of even the exterior line, they were obliged to retire from Portugal, closely followed and harrassed by the army which they had previously driven out of Spain. Yet though the lines of Torres Vedras were thus perfect in themselves, and though one of the ablest of the French generals and a veteran French army were foiled before them, it is not meant to refer to this system of separate field-works as a model to be followed on all occasions; for whilst the old method of covering a considerable front by a continued line of regular bastions and curtains has been universally condemned by modern engineers, it is nevertheless certain that there are situations where a partial application of continued lines may be most judiciously made. In fact, it is not by any fixed rule, but from the nature of the ground and of the position to be defended, that the species of works calculated to be most useful should, in every case, be determined.

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[1] *Military Maxims* of Napoleon.

[2] *War in Spain*, p. 124. The French army which invaded Portugal under Massena consisted of three corps, under Marshals Ney and Junot and General Regnier, amounting in all to 66,000 infantry and 6000 cavalry, besides a strong body of the imperial guard, which crossed the Pyrenees after the invading force had commenced its march from the neighbourhood of Salamanca. The force collected to oppose this threatened invasion did not exceed 48,000 infantry and 3000 cavalry, of which about a half was composed of Portuguese levies, yet untried in any general action, and of which a very unfavourable opinion still continued to be entertained. In point of numbers, and still more in the composition of their army, therefore, the French had a decided superiority; but all their advantages were neutralised by the defensive position of Torres Vedras.

[3] *History of the War in the Peninsula*, vol. iii.

It must be obvious indeed that even a limited knowledge of the art of war opens a wide field for the exercise of the talents and resources of engineers in field fortification; but the possession of a military coup-d'œil, or of that intuitive judgment which comprehends at a glance the true bearing or character of objects as well as events, is necessary to enable them to convert theoretical stores of information to the best practical uses. In passing through a country, it requires an experienced eye to seize quickly on whatever it presents calculated to prove advantageous or disadvantageous to an army destined to attack or defend it; to appreciate the value of villages, stone-enclosures, and broken ground; to know where to dam up rivers, to scarp heights, to form abattis, trous-de-loup, and other obstacles; to select the best situations for field-forts and redoubts, and the best emplacements for batteries; and to arrange all the defensive means employed, with reference to the number of troops destined to act upon the different parts of the line, so that the movements of the defenders may not be obstructed or retarded, and the communications throughout may be short and easy. The variety of ground, however, upon which military operations are for the most part carried on, precludes the possibility of laying down fixed rules in regard to this subject; the accidents of ground, and the peculiar circumstances of each individual case, must, as already observed, determine the extent and description of the works to be constructed, as well as the obstacles most proper to be formed for retarding, if not obstructing, the advance of an enemy.[1]

At the same time, though the observance of fixed rules be impracticable, general principles are of universal application; and hence some of the received maxims in permanent fortification hold equally good in regard to the construction of field-works. These are, *first*, that the works to be flanked must never be beyond the range of the missiles discharged from the works flanking them, or in other words, never out of the effective range of musketry, that is, from 150 to 200 yards; *secondly*, that the angles of defence should be about right angles; *thirdly*, that the salient angles of all works should be as obtuse as possible; *fourthly*, that though ditches cannot always be as fully flanked as in permanent fortification, yet partial flanking must be carried as far as possible; and, *fifthly*, that in the construction of field-works, reference should not only be had to the direct and immediate obstacles which the work itself is calculated to present to the enemy, and the positive effect of the fire on the approaches to it, but the relative value of the work should likewise be considered, with respect to the support it can receive from or give to other works. These principles or maxims are of invariable application.

It is usual to divide field-works into three classes: *First*, works open at the gorge; *secondly*, works enclosed all round; and, *thirdly*, lines at intervals.

Redans, or simple heads	fig. 1,	are the names given to the various tracings of the first class, or open works.
Double redans, or queues d'hironde	fig. 2,	
Tenailled heads	fig. 3,	
Bastioned heads	fig. 4,	
Redoubts	fig. 5,	are the names given to works of the second class, that is, closed works.
Star-forts	fig. 6,	
Bastioned forts	fig. 7,	
Lines à crémaillières	fig. 8,	are the names given to works of the third class, or lines at intervals.
Lines of redans	fig. 9,	
Lines of tenailles	fig. 10,	
Lines of bastions	fig. 11,	
Lines at intervals	fig. 12,	

The first class are of the simplest kind of field-works, and serve as a mere cover in front of avenues, bridges, causeways, and the like; but being quite open at the gorge, they are only suited for defence when their extremities rest on rivers, or obstacles which prevent their being turned, or when within the full sweeping fire of works in their rear. To increase the strength of a *redan*, its faces are sometimes broken into a kind of flank, as in fig. 1, Plate CCXLIX. The *double redan*, or *queue d'hironde*, fig. 2, is considerably stronger, as the re-entering faces defend each other; the *tenailled heads* in situations which require a greater extent of front; and the *bastioned heads* are also employed in similar circumstances. See fig. 3 and 4.

Redoubts are works closed on all sides; they are constructed of a square or polygonal figure, but most commonly square, as, when of this form, each front can furnish a strong perpendicular fire. Provision should be made for defending the ground before the angles, which, however, are sometimes rounded or cut *en crémaillière*, so that a fire may be delivered from them. See fig. 5.

Star-forts were proposed in order to remedy the defects of redoubts having the ground before them undefended by a flanking fire, so that a cross fire might be delivered from the adjacent sides. But, according to Jomini, "star-forts are the very worst description of fortification; they cannot have flanks, and the re-entering angles take so much from the interior space that it is impossible to place troops and artillery in them sufficient for their defence:" an opinion confirmed by the practice of Sir Richard Fletcher and Sir John Jones in the construction of the lines of Torres Vedras, where the trace of the redoubts was made subservient to the conformation of the ground, to the object in view, and to the protecting them as much as possible from the fire of the enemy's position.

In *bastioned forts*, fig. 7, the principles of construction correspond with those detailed in permanent fortification; and the flanking defence thus obtained for the ditch is nearly perfect. As bastioned forts are only constructed in cases of great importance, no labour or expense should be spared in the formation of such works.

Forts with demi-bastions, fig. 12, are objectionable, as the ditches are only defended by an oblique fire from the sides. The parapets of these works should be of sufficient thickness to resist the fire of the heaviest guns that can be brought against them. In some cases, however, the parapets need only be strong enough to resist the fire of light field-guns, whilst in others it will be sufficient if they serve as a cover to the men within them against musketry. The latter kind is generally that which is thrown up in an evening after taking up a position, and which, if the army does not move next day, it may be considered as necessary to strengthen in some parts, according to circumstances.

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[1] Shaw's *Course of Field Fortification*, p. 9, et seqq. To the author of this useful tract we have been indebted for valuable assistance in the compilation of the present article, the plates connected with which are engraved from drawings either executed by him or under his inspection.

Continued lines, or connected works, are resorted to in order to enclose the front, or to connect important works or forts. The most simple tracing is that of redans joined together by curtains, fig. 9; but as the ditches of these curtains can only be defended by an oblique fire from the faces of the redans, this defect may be remedied by breaking the curtains so as to form nearly right angles with the faces of the redans, in which case they are called *lines of tenailles*.

Lines en crémaillère have long faces, with flanks perpendicular to these, in order to defend their ditches. When these faces can be directed towards ground upon which it is impracticable to establish enfilading batteries, the construction is considered as good.

Bastioned lines are the strongest trace which can be given to continued lines, when the ground will admit of such. A perfectly regular trace is only suited for level ground. The ditches in field-works are often sloped *en rampe* towards the adjoining flanks, in order that the *deblai*, or quantity of earth excavated, may not exceed the *remblai*, or quantity contained in the mass of the rampart or parapet, a circumstance which often occurs in field-works, where there is seldom any rampart, and only cover sufficient for the defenders.

Lines with intervals, fig. 14, shows the general trace of lines of this kind. The salient works should never be beyond the range of musketry from the re-entering works, and the angles of defence between the two lines should be as near as possible to right angles.

Têtes-de-pont, or *bridge-heads*, are works generally open at the gorge, and whose flanks rest upon a river, in order to cover one or more bridges. The best situation for these works is the re-entering sinuosity of a river. As têtes-de-pont, fig. 13, are usually constructed for the purpose of enabling a retiring army to cross a river in order, and to check an enemy pressing upon it, the tracing and profile should be such as to secure a double advantage to the greatest extent possible. In Sir Howard Douglas's able work on the Construction of Military Bridges will be found much valuable scientific information upon this important subject.

To field-works there are usually added a variety of obstacles, in order to render the approaches more difficult to the enemy; such as *palisades*, *barriers*, *abbatis*, *trous-de-loup*, *chevaux-de-frise*, *harrows*, and *crows'-feet*.

Palisades are strong stakes fixed in the ground, and well sharpened at the upper extremities. They are sometimes placed horizontally in the face of the parapet, in which case they are called *fraises*. *Barrier-gates*, for closing the entrances of field-works, should be made strong enough to resist a sudden attack; they are always placed on the most inaccessible side. *Abattis* are lines of felled trees of considerable size, strongly bound together and picketed down, with the smaller branches cut off, and the remainder sharpened and pointed towards the enemy. They are interlaced as much as possible. Abattis, well disposed, present a formidable obstacle. *Trous-de-loup* are rows of pits, made before a work, in the form of inverted cones, having each a strong palisade or stake in the middle. *Chevaux-de-frise* are formed by inserting iron-pointed stakes, five or six feet in length, into a heavy beam of wood, which will thus, if it be square, present four projecting spears, and if hexagonal, six. Chevaux-de-frise are generally chained together in a line, in order to cover the ground required; and sometimes they are so constructed as to revolve on an axis. *Harrows*, such as those ordinarily used in husbandry, are recommended to be spread, with the teeth uppermost, over the ground by which an enemy, particularly cavalry, is likely to advance to the attack. *Crows'-feet* are pieces of iron, with four points, each four or five inches long, projecting in different directions, and also intended to impede the advance of cavalry.

For *the defence of open towns and villages*, the following methods, recommended by the French minister of war in 1814, are considered as the best that have yet been suggested: "To admit of a town being advantageously intrenched, it is necessary that it should not be commanded within any short distance, that the houses should not be of a construction easily set on fire, and that its extent should not be out of proportion to the means and time at the disposal of the defenders. The first thing to be done is to clear the approaches to the town, by levelling houses, hedges, shrubberies, and whatever may favour the assailants. Wood ought to be cut two feet from the ground, that it may serve to impede the advance of the enemy without masking the fire of the defenders. The next object is to form or complete the enclosure round the town. For this purpose advantage is taken of buildings, walls, and fences applicable to the defence. The openings which remain must be closed by palisades, stockades, or ditches strengthened by abattis. All streets leading out of town must be barricaded. The barricades must be sufficient to resist field artillery, and high enough not to be easily got over; and they ought to be flanked by loopholing the neighbouring houses. When pressed for time, carts filled with dung and the wheels taken off, sand-bags, bales of wool or cotton, and furniture taken from the neighbouring houses, all form good barricades. If there should be any old castle, church, or large substantial building, it should be converted into a keep, by blocking up useless entrances, loopholing walls, and surrounding them by a ditch or abattis. If a town is situated near a stream or river, by which part of it may be covered by inundations, this should never be neglected."

Villages are intrenched on similar principles, and being generally surrounded by gardens with live hedges, the latter may be made use of in forming the lines of defence. If there should only be sufficient troops to defend part of a village or town, a part only should be intrenched and separated from the rest by means of carts and barricades. If there are very few houses, it may be necessary to confine the defence to the church or churchyard, which may in all cases serve as a sort of keep.

The destruction of bridges. Nothing is of greater consequence to a retiring army than to be able to destroy the bridges in its rear, in order to retard the advance of the enemy. Its safety, nay even its existence, may depend upon the success with which this operation is performed. In order to destroy a stone-bridge, a trench in the form of a cross is made in the crown of the arch, the branches of which are about ten feet in length, and sunk to the top of the arch-stones. A hundred and sixty pounds of powder are placed in each cut or trench for an arch three feet thick, strong planks are then laid over the powder, and the whole being well covered with rubbish, the fire is communicated by means of saucisson or long powder-hose. Stone bridges are also destroyed by simply cutting a trench about eighteen inches deep across the crown of the arch, and placing in it 345 pounds of powder covered in the manner just described. This quantity has been found sufficient to destroy semicircular arches of twenty-five feet in span, and three feet in thickness at the key. Wooden bridges may be destroyed in different ways;

they may be pulled to pieces, burned, or blown up. When there is time to take them to pieces, they are unspiked, and the timbers so separated that they may be speedily removed. The best method of burning such bridges is to tar them, and to cover and surround them with fascines or tarred brushwood. When it is necessary to blow up wooden bridges, this may be effected by means of 220 pounds of powder suspended under the superstructure, and fired in the manner above described.

A *ford* is rendered impassable by throwing in large stones, by sinking boards with spikes standing upright in them, by scattering in it crows'-feet, or by placing harrows taken from the neighbouring farms. A low wall may also be built across, so as not to be perceptible above the water; strong stakes may be driven into the bottom, and trees fastened to them; waggons loaded with stones, and the wheels taken off, may in like manner be employed; not to mention a number of other things which may be easily found, and which will answer the purpose equally well. The rendering a ford impassable by such means is only second in importance to the destruction of a bridge, when the enemy whose progress it is desired to retard has either no pontoon-train at all, or has outstripped it by the rapidity of his advance. In this way much valuable time may be gained on the one hand and lost on the other.

(A.)

FORTIFIED ISLAND, an island in the Indian Seas, lying off the coast of Canara, about a mile from the land, a little way north from the entrance into Lake Onore. The island abounds in cocoa-nut, palms, and plantain trees, and has plenty of fresh water. It produces the best sort of cari, which is used by the natives in painting their houses. Its name is derived from its fortifications, which were greatly strengthened by Tippoo Saib, from whom it was taken in 1792, by three British frigates. It is upwards of a mile in circuit. Long. 74. 27. E. Lat. 14. 16. N.

FORTISSIMO, in *Music*, sometimes denoted by FFF, or *fff*, signifies to sing or play very loud or strong.

FORTITUDE, a virtue or quality of the mind, which is generally considered to be the same as courage, though in a more accurate sense the one may be distinguished from the other. Courage may be a virtue or a vice, according to circumstances; fortitude is always a virtue. We speak of desperate courage, but not of desperate fortitude. A contempt or neglect of danger, without regard to consequences, may be called *courage;* and this some brutes possess as well as man. In them it is chiefly the effect of natural instinct; in man it depends partly on habit and partly on strength of nerve. But fortitude being the virtue of a rational and considerate mind, is founded on a sense of honour and a regard to duty.

This virtue takes different names, according as it acts in opposition to different sorts of evil; but some of these are applied with considerable latitude. With respect to danger in general, fortitude may be termed *intrepidity;* with respect to the dangers of war, *valour;* with respect to pain of body or distress of mind, *patience;* with respect to labour, *activity;* with respect to injury, *forbearance;* with respect to our condition in general, *magnanimity.*

The motives to fortitude are many and powerful. This virtue tends greatly to the happiness of the individual, by giving composure and presence of mind, and keeping the other passions in due subordination. To public good it is essential; for without it the independence and liberty of nations would be impossible. It gives to a character that elevation which poets, orators, and historians, have in all ages rejoiced to celebrate. Nothing so effectually inspires it as rational piety; the fear of God is the best security against every other fear. A true estimate of human life, particularly its shortness and uncertainty, together with the numberless evils and temptations to which, by a long continuance in this world, we must unavoidably be exposed, ought by no means to discourage or to throw any gloom on our future prospects, but should teach us that many things are more formidable than death, and that nothing is lost, but much gained, when, by the appointment of Providence, a well spent life is brought to a conclusion.

FORTUNA, the goddess of fortune, worshipped by the Greeks and Romans, became particularly celebrated after the triumphs of the latter. According to Hesiod, she was the daughter of Oceanus and Tethys, the sister of the Parcæ, and the protectress of cities. The sculptor Bupalus represented her with a celestial globe on her head, and a cornucopia in her hand. She had temples in Smyrna, Corinth, and Elis; but it was at Rome where she seems to have been more particularly worshipped, and where she had upwards of twenty shrines erected to her honour. There was a magnificent temple of Fortune at Præneste, now Palestrina, eighteen miles east from Rome. Here was the celebrated oracle called *Sortes Prænestinæ*, where the response was given by means of words written on pieces of wood, which were placed in a box, and having been taken out at random, were then united, when the priest declared the meaning of the answer. The first Mosaic pavement introduced into Italy was ordered by Sylla for this temple; and it is a curious fact that a very fine specimen is still seen at Palestrina, which may possibly be that to which we have alluded.

FORTUNATÆ INSULÆ, the name by which the Canary Islands were known to the ancients. The Carthaginians were no doubt acquainted with these islands at an early period, but it was the selfish nature of their policy to confine such knowledge to themselves, for the sake of the commercial advantages to be derived from it. It was not, therefore, till the fall of Carthage that the Greeks and Romans acquired any accurate information respecting the islands on the west coast of Libya. Statius Sebosus, the friend of Lutetius Catulus, consul 242 B.C., and who flourished in the time of the Cimbrian war, could not have been the first who made the discovery, though he was probably the first who gave a description of them to the public. Of this account we possess only a few notices by Pliny, who seems to have derived no information from any other quarter. Yet there must have been considerable intercourse with these islands, as we find that Sertorius, when flying before the superior force of the party of Sylla, was so charmed with the account of them he received from some sailors, that he was strongly tempted to take refuge there. The name seems at first to have been restricted to two, Convallis, the island of *Teneriffe*, and Planaria, now *Canaria*, from which the Canary Islands derive their name. Ptolemy extends the name to six islands. (Strab. i. 3; Plin. vi. 32; Plut. Sert. 9; See Minano, *Diccionario Geografico*, &c. Madrid, 1826.)

FORTUNE (*Τυχη*), a name which, amongst the ancients, seems to have denoted a principle by which things came to pass, without being necessitated thereto; but what that principle was, or whence it proceeded, they do not seem to have precisely considered. Hence their philosophers often intimate that men only conjured up the phantom of Fortune to hide their own ignorance; and that thus they call Fortune whatever befals a man without his knowing for what purpose. Hence Juvenal (*Sat.* x. ver. 366) affirms, there were men who made a deity of fortune.

> Nullum numen abest, si sit prudentia; sed te
> Nos facimus, Fortuna, deam, cæloque locamus.

According to the opinion of the heathens, therefore, Fortune was in reality only the occurrence of things in a sudden and unexpected manner, without any apparent cause or reason; so that the philosophical sense of the word coincides with what is commonly called *chance*.

But in religion the term had much greater force; for altars and temples in great numbers were consecrated to Fortune as a deity. This intimates that the heathens had personified, and even deified chance; conceiving it a sort of goddess who disposed at pleasure of the fate of men. Hence the invocation of Horace, *O diva, gratum quæ regis Antium*, in which he recommends Augustus, then preparing for a visit to Britain, to the protection of this divinity. From all this it may be inferred that the ancients at one time considered Fortune as a peremptory cause, operating in order to do good to some, and evil to others; and at another as a blind inconstant cause, without any view or determination at all. If, then, the word Fortune had no certain meaning even amongst those who erected altars in honour thereof, much less can it be ascertained what the term denotes in the minds of those who now use the word in their writings. They who would substitute the term *Providence* instead of that of *Fortune*, cannot give any tolerable sense to half the phrases in which the word occurs.

Horace paints the goddess as preceded by Necessity, holding nails and wedges in her hands, with a cramp-iron, and molten lead to fasten it, but rarely accompanied with Fidelity, unless when she abandons a family, in which case Fidelity never fails to depart with her, as well as friends. Fortune is disrespectfully spoken of by most of the Roman writers, and represented as blind, inconstant, unjust, and delighting in mischief (Ovid. *ad Liv.* ver. 52, ver. 374; Hor. lib. i. od. 34, ver. 26, lib. iii. od. 29, ver. 15; Statius, Theb. xii. ver. 505). However, they had a good as well as a bad fortune, a constant and an inconstant fortune, the latter of which was represented with wings, and a wheel beside her (Hor. lib. iii. od. 29, ver. 56). Juvenal alludes to a statue of Fortune, which exhibited her under a good character, as the patroness of the poor infants who were exposed by their parents in the streets (*Sat.* vi. ver. 605). The painters commonly represent her in a woman's habit, with a bandage over her eyes, to show that she acts without discernment; and standing on a wheel, to express her instability. The Romans, says Lactantius, represented Fortune with a cornucopia, and the helm of a ship, to show that she distributes riches, and directs the affairs of the world. In effect, it is by such characters that we see her represented upon so many medals, with the inscription, FORTUNA AVG. FORTUNA REDVX, FORTVNÆ AVG. or FORTUNÆ REDVCIS, and so on. Sometimes she is seen pointing at a globe before her feet, with a sceptre in one hand, and holding the cornucopia in the other.

The Romans had a male as well as a female Fortune which were objects of adoration; the *Fortuna virilis* being honoured by the men, and the *Fortuna muliebris* by the women. They appear to have derived the worship of Fortune from the Greeks under the reign of Servius Tullius, who dedicated to her the first temple in the public market-place. Nero also built a temple to Fortune. The Fortune worshipped at Antium was probably the most exalted of any amongst the Romans, if we may judge by the account which Horace gives us of the solemn processions that were made to her (Hor. lib. i. od. 35, ver. 22). But the most celebrated temple of Fortune was at Præneste; and Statius speaks of several, whom he calls the *Prænestinæ Sorores* (lib. i. Sylv. iii. ver. 80).

FORTUNE ISLANDS, two small islands in the Eastern Seas, one near the south-west coast of the island of Sumatra, in long. 90. 25. E. and lat. 1. 35. S.; the other near the north coast of the island of Celebes, in long. 123. 48. E. and lat. 0. 50. N.

FORUM, in Roman antiquity, a public place within the city of Rome, where causes were judicially tried, and orations delivered to the people.

FORUM was also used for a place of traffic, and answered to our market-place. These places were generally called *fora venalia*, in contradistinction to the former, which were called *fora civilia*.

The *fora civilia* were public courts of justice, commonly magnificent in themselves, and surrounded with porticoes and stately edifices. Of these, six were very remarkable: 1. *Forum Romanum;* 2. *Julianum;* 3. *Augustum;* 4. *Palladium;* 5. *Forum Trajani;* and, 6. *Forum Sallustii.* The *Forum Romanum* was the most noted, and is often styled simply *Forum*, by way of eminence. Here were the bar called *Rostra*, the *Comitium*, the sanctuary of *Saturn*, the temple of *Castor*, and other remarkable edifices. Of the *fora venalia*, or market-places, which were numerous, the chief were, the *forum boarium*, for oxen or beef; *suarium*, for swine; *pistorium*, for bread; *cupedinarium*, for dainties; and *olitorium*, for garden stuffs.

The Grecian αγοραι corresponded exactly with the Roman *fora*, being places where courts and markets were indiscriminately held. At Athens they had many *fora*, but the chief of these were the *old* and the *new*.

FORUM Indicere was the act of the prætor appointing the place in Rome where causes were to be tried. *Agere forum* denoted the bringing on causes out of Rome, in a Roman province, and was the same with *agere conventum.*

FOSS, or FOSSE, in *Fortification*, a ditch or moat. The word in French is formed from the participle *fossum*, of the Latin verb *fodio*, I dig.

Foss, *Fossa*, in *Anatomy*, a kind of cavity in a bone, with a large aperture, but no exit or perforation. When the aperture is very narrow it is called a *sinus.*

Foss is particularly used for the cavity or indenture in the back part of the neck.

FOSSA, in our ancient customs, was a ditch full of water, where women who had committed felony were drowned. *Nam et ipsi in omnibus tenementis suis omnem ab antiquo legalem habuere justitiam, videlicet ferrum, fossam, furcas, et similia.* In another sense it is used to signify a grave, as appears by these old verses:

> Hic jacent in fossa Bedæ Venerabilis ossa:
> Hic est fossatus, qui bis erat hic cathedratus.

Foss-Way was anciently one of the four great Roman highways of England, and, according to Camden, was so called because it was ditched on both sides, this having been the Roman method of making highways.

FOSSANO, a city of the province Cuneo, in the kingdom of Sardinia. It is situated on the river Stura, is fortified, and contains a cathedral, five other churches, six monasteries, two nunneries, and 14,000 inhabitants. It is a place of consideration, from its extensive silk manufactures, and from its tanneries. There is also much trade in wine, corn, hemp, and other products of the soil.

FOSSARII, in *Antiquity*, a kind of officers in the Eastern Church, whose business it was to inter the dead. Ciaconius relates that Constantine created nine hundred and fifty fossarii, whom he took out of the different colleges or companies of tradesmen; and he adds, that they were exempted from taxes, services, burdensome offices, and the like. Goar, in his notes on the Greek *Euchologion*, insinuates that the *fossarii* were established in the times of the apostles; and that the young men who carried off the body of Ananias, and those persons full of the fear of God who interred St Stephen, were of the number. St Jerome assures us that the *fossarii* held the first place amongst the clerks;

but he is to be understood of those clerks only who had the direction and superintendence of the interment of the devout.

FOSSIL, in *Natural History*, denotes in general every thing that is dug out of the earth, whether it be native thereto, as metals, stones, salts, earths, and other minerals, or extraneous, as the bones of animals, and the like.

Native fossils are substances found in the earth or on its surface, of a simple structure, exhibiting no appearances of organization, and included under the general names of simple and compound, earthy or metallic minerals. *Extraneous* fossils are bodies of the vegetable or animal kingdoms accidentally buried in the earth. Of the vegetable kingdom there are principally three kinds, trees or parts of them, herbaceous plants, and corals; and of the animal kingdom there are four kinds, sea shells, the teeth or bony palates and bones of fishes, complete fishes, and the bones of land animals. See MINERALOGY.

FOSTER, JAMES, a nonconformist divine, highly celebrated for his pulpit eloquence and erudition, was born at Exeter in the year 1697. At the age of five he was put to the free school of that city, where his progress in the acquisition of grammar was so rapid that his master boasted of him as the most eminent genius in his school. From this seminary he went to the academy where young men designed for being clergymen in the dissenting interest were educated, and here his progress was equally great. His apprehension was remarkably quick, his judgment solid, his memory retentive, his eloquence commanding, and his talents for argumentation truly admirable; but above all, his piety was genuine, and few men possessed candour, modesty, liberality, integrity, tenderness, and benevolence, in so remarkable a degree. He commenced preacher at the age of twenty-one, and was much admired where he occasionally officiated. But the doctrine of the Trinity, which was then much agitated in the west of England, did not accord with the notions of Mr Foster, and the honesty and openness of his heart would not suffer him to conceal his opinions, which, in fact, brought so much odium upon him from the orthodox party, that he retired to another scene of action. He became pastor of a congregation at Milborne-port, in Somersetshire; but as soon as his hearers became zealously attached to what was deemed the orthodox opinion, he retired to Ashwick, under the Mendip Hills, in the same county. In this asylum he preached to two congregations at a little distance from each other, the united contributions of which did not amount to L.15 per annum. In this state of poverty and obscurity he lived for some years, submitting patiently to the privations which were occasioned by his determined uprightness and sincerity. In 1720 he gave the world his *Essay on Fundamentals*, the design of which was to check an uncharitable and intolerant spirit, at that time extremely prevalent, by showing that the Trinitarian notion is not a fundamental article of Christianity, or made an express condition of salvation in the sacred Scriptures. A sermon accompanied this essay, entitled *The Resurrection of Christ proved and vindicated*, against the most important objections of the ancient Jews or modern Deists. From Ashwick, Foster removed to Trowbridge in Wiltshire, where his congregation did not usually exceed twenty or thirty persons.

By reading Dr Gale's treatise on infant baptism, he became a convert to the doctrine, that immersion is the true scriptural rite, and was accordingly soon afterwards baptized in London in conformity to that mode. This unreserved manner of adopting whatever his conscience believed to be truth, excluded him from almost every religious party amongst whom he might otherwise have expected preferment. But whilst he deliberated with himself whether he should abandon the ministry, and acquire the knowledge of some mechanical employment, Mr Robert Houlston received him into his house in the capacity of chaplain, and here his circle of acquaintances became wider and more respectable. In 1724 he was appointed to succeed Dr Gale in the Baptist congregation in Barbican, London. In 1728 he commenced a Sunday evening lecture in the Old Jewry, which he continued till within a short time of his death, with a degree of popularity which few dissenters at that time enjoyed. In 1732 appeared his work entitled The Usefulness, Truth, and Excellency of the Christian Revelation, defended against the objections contained in a late book, called *Christianity as old as the Creation*. In this reply Mr Foster exhibited no ordinary share of talents and ingenuity, and it was admired by the candid and judicious of every description. Dr Tindal, against whom it was written, is said to have always spoken of it with great respect. He published a volume of sermons in the year 1734, followed by three other volumes, the last of which appeared in 1744. At this time he was appointed successor to Dr Jeremiah Hunt, in the protestant congregation at Pinner's-hall. In 1746 he attended the Earl of Kilmarnock when under sentence of death for high treason, after which he published an octavo pamphlet, containing An Account of the Behaviour of the late Earl of Kilmarnock after his Sentence, and on the day of his Execution.

Foster received from Marischal College, Aberdeen, the degree of doctor in divinity, accompanied with handsome letters from the Principal and Professor Fordyce. "We beg," said the latter, "that you will be so good as to accept of the diploma, as a small mark of the sincere veneration we have for you, and of the sense we entertain of the eminent services you have done to the cause of liberty, religion, and virtue, by your writings as well as public instructions." The first volume in quarto of his *Discourses on all the principal Branches of Natural Religion and Social Virtue*, was published in the year 1749, and the second appeared in 1752. They were published by subscription; and to evince the high estimation in which his talents and virtues were held, two thousand names were contained in the list, many of them those of persons distinguished by their rank and literary abilities.

In the month of April 1750 he was seized with a violent distemper, from the effects of which he never thoroughly recovered; yet whilst at all able to officiate, he continued to preach till the beginning of 1752, when he had another attack, which seems to have been of a paralytic nature. After suffering for some time, he expired on the 5th of November, in the fifty-fifth year of his age. His private and public life were alike irreproachable. Foster, it appears, would have died in indigent circumstances, had it not been for the numerous subscriptions to his discourses on natural religion.

Besides the works above noticed, Dr Foster published three funeral sermons, one of which was intended for Mr Emlyn; together with a number of essays which appeared in the Old Whig.

FOSTER, *Samuel*, an English mathematician and professor of astronomy at Gresham College, was one of that learned association which met for cultivating the new philosophy, and which Charles II. established as the Royal Society. Mr Foster, however, died in 1652, before this incorporation took place; but he wrote a number of mathematical and astronomical treatises, particularly, 1. The Description and Use of a small portable Quadrant, for the more easy finding of the hour of azimuth, 1624, in 4to; 2. The Art of Dialling, 1638, in 4to; 3. *Posthuma Fosteri*, containing the description of a Ruler upon which are inscribed divers scales, 1652, in 4to; 4. Four

Treatises of Dialling, 1654, in 4to; 5. The Section altered, and other scales added, with the description and use thereof, 1661, in 4to; 6. Miscellanies, or Mathematical Lucubrations. Of the treatises in this collection some are written in Latin and others in English.

There were two other persons of this name who published mathematical works; William Foster, a disciple of Mr Oughtred, who taught in London; and Mark Foster, author of a treatise on trigonometry, who lived later than the former.

FOTHERGILL, Dr George, was born in Westmoreland in 1705, where his family had long possessed a competent estate, which had descended regularly for several generations. After receiving an academical education in Queen's College, Oxford, of which he became a fellow, he was, in 1751, elected principal of St Edmund's Hall, and presented to the vicarage of Brumley in Hampshire. Having been long afflicted with an asthma, he died of that disease in 1760, at the age of fifty-five. He was the author of a collection of sermons, in 2 vols. 8vo; the first consisting of occasional discourses, published by himself, and the second being printed from his manuscripts.

Fothergill, *Dr John*, an eminent physician, was born of Quaker parents, in 1712, at Carr End in Yorkshire, where his father, who had been a brewer at Knaresborough, lived retired on a small estate which he cultivated. The doctor was the second of five children, and received his education under the care of his grandfather Thomas Hough, a person of fortune in Cheshire (which gave him a predilection for that county), and at Sedbergh in Yorkshire. Having served his time to Mr Bartlett, an apothecary at Bradford, he removed to London, and became a pupil of Dr, afterwards Sir Edward, Wilmot, at St Thomas's Hospital. He then went to the university of Edinburgh for the purpose of studying physic, and there took his doctor's degree. From Edinburgh he went to Leyden, but after a short stay he returned to London, and began to practise about the year 1740, in a house in White-hart Court, Lombard Street, where he resided during the greater part of his life, and acquired most of his fortune. In 1746 he was admitted as a licentiate of the College of Physicians in London; and in 1754 as a fellow of that of Edinburgh, to which he was a considerable benefactor. He afterwards became a member of the Royal Medical Society at Paris, and a member of both the Royal and Antiquarian Societies. He continued his practice with uninterrupted success till within the two last years of his life, when an illness, which had been brought on by unremitting attention, obliged him to give up a considerable part of it. Besides his application to medical science, he had imbibed an early taste for natural history, and employed himself on conchology and smaller objects of botany. He had a very extensive practice, but he did not add to his art any great or important improvements. His pamphlet on the ulcerous sore throat is the best of his publications, but it owes much of its merit to the information of the late Dr Letherland. It was printed in the year 1748, on the re-appearance of that fatal disorder which in 1739 had carried off the two sons of Mr Pelham. In 1762 Dr Fothergill purchased an estate at Upton in Essex, and there formed a botanic garden. In 1766 he began, between Midsummer and Michaelmas, to withdraw from the excessive fatigue of his profession, and took no fees during this recess. For some time before his death he had been endeavouring to contrive a method of generating and preserving ice in the West Indies. He was the patron of Sidney Parkinson, and drew up the preface to his account of the voyage to the South Seas. At his expense also was made and printed an entirely new translation of the Bible, from the Hebrew and Greek originals, by Anthony Purver, a Quaker, in two volumes, 1764, folio; and also, in 1780, an edition of Bishop Percy's *Key to the New Testament*, adapted to the use of a seminary of young Quakers, at Ackworth, near Leeds in Yorkshire, founded in 1778 by the Society, who purchased, by a subscription, in which Dr Fothergill stood foremost, the house and an estate of thirty acres which the Foundling Hospital held there, but which they found inconvenient for their purpose. The doctor himself first projected this on the plan of a smaller institution of the same kind at Gildersomes, and endowed it handsomely by his will. It now contains above three hundred children of both sexes, who are clothed and instructed. Amongst the other beneficent schemes suggested by Dr Fothergill, were those of bringing fish to London by land carriage, which, though it did not in every respect succeed, certainly tended to destroy a supposed combination; and of rendering bread much cheaper, though equally wholesome, to the poor, by making it of one part of potatoes mixed with three parts of household flour. But all his public benefactions, his encouragement of science, and the instances of his attention to the health, police, and convenience of the metropolis, we cannot pretend to specify. The fortune which Dr Fothergill had acquired was great, amounting to about L.80,000. His business, when in full practice, was calculated at near L.7000 per annum. In the influenza of 1775 and 1776, he is said to have had sixty patients on his list daily, and his profits were estimated at L.8000 per annum. The disorder which hastened his death was a schirrus of the prostate gland, and an obstruction of the bladder. He died at his house in Harpur Street, in the month of December 1780, and his remains were interred in the Quakers' burying-ground at Winchmore Hill. The doctor by his will appointed that his shells and other pieces of natural history should be offered to Dr Hunter at L.500 under the valuation which he had ordered to be taken of them, and accordingly Dr Hunter bought them for L.1200. His drawings and collections in natural history were also offered to Sir Joseph Bankes at a valuation. His English portraits and prints, which had been purchased by him for eighty guineas, were bought by Mr Thane for two hundred guineas. His books were sold by public auction.

FOUGASSE, in the art of war, a small mine from six to eight feet under ground, and generally placed under the glacis, or in dry ditches. It is charged with sacks of powder covered with earth and stones, and, like larger mines, is fired by means of a saucisson.

FOUL, in nautical language, is used when a ship has been long untrimmed, so that grass weeds, or barnacles, grow on her sides under water. A rope is also foul when it is either tangled in itself, or hindered by another from running or being overhauled.

Foul imports also the running of one ship against another. This happens sometimes by the violence of the wind, and sometimes by the carelessness of the people on board, to ships in the same convoy, and to ships in port by means of others coming in. The damages occasioned by running foul are of the nature of those in which both parties must bear a share. They are usually made to fall half upon the sufferer, and half upon the vessel which did the injury; but in cases where it is evidently the fault of the master of the vessel, he alone must bear the damage.

FOUCHENGE, a town of Persia, in the province of Khorassan, twenty-five miles north of Herat. Long. 76. 29. E. Lat. 34. 50. N.

FOUL Islands, a cluster of small islands in the Indian Sea, near the north coast of the island of Flores. Long. 121. 22. E. Lat. 8. 9. S.

FOULA, or Fowla Island, one of the Zetland Isles, lying between six and seven leagues west from the main land. It is about three miles in length, narrow, and full of rough, steep, and bare rocks; one of which is so large, and runs up to such a height, that it may be clearly seen from Orkney. This solitary isle, it has been conjectured, is the Thule of Tacitus. It is pastoral, and maintains a few families.

FOULAHS, a people of Africa, who inhabit the confines of the Sahara, or Great Desert. The principal of the Foulah states is that within Sierra Leone, and of which Teembo is the capital.

FOUMART, a species of Mustela. See Mammalia.

FOUNDATION, in *Architecture*, is that part of a building which is under ground.

Foundation denotes also a donation or legacy, either in money or lands, for the maintenance and support of some community, hospital, school, or other institution.

FOUNDERY, or Foundry, the art of melting and casting all sorts of metal, such as brass, iron, &c. See Brass-making, and Iron-making; also the article Furnace.

Foundery of Small Works, or Casting in Sand. The sand commonly used for casting small works is at first of a pretty soft, yellowish, and clammy nature; but it being necessary to strew charcoal dust in the mould, it at length becomes of a quite black colour. The sand is worked over and over, on a board, with a roller and a sort of knife; and is placed over a trough to receive it, after it has by these means been sufficiently prepared.

This being done, the workmen take a wooden board of a length and breadth proportional to the things to be cast, and putting a ledge round it, they fill it with sand a little moistened, to make it duly cohere. They then take either wood or metal models of what they intend to cast, and apply them to the mould, and press them into the sand so as to leave their impression there. Along the middle of the mould is laid half a small brass cylinder, as the chief canal for the metal to run through, when melted, into the models or patterns; and from this chief canal are placed several others, which extend collaterally to each model or pattern placed in the frame. After this frame is finished, they take out the patterns, by first loosening them all round, that the sand may not give way; then they proceed to work the other half of the mould with the same patterns in just such another frame, only that it has pins, which, entering into holes corresponding to it in the other, make the two cavities of the pattern fall exactly on each other.

The frame, thus moulded, is carried to the melter, who, after extending the chief canal of the counterpart, and adding the cross canals to the several models in both, and strewing mill dust over them, dries them in a kind of oven prepared for the purpose. Both parts of the mould being dry, they are joined together by means of the pins; and to prevent them giving way, by reason of the melted metal passing through the chief cylindrical canal, they are screwed or wedged up like a kind of press.

Whilst the moulds are thus preparing, the metal is fusing in a crucible of a size proportional to the quantity of metal intended to be cast. When the moulds have cooled, the frames are unscrewed or unwedged, and the cast work taken out of the sand, which sand is worked over again for other casting.

Foundery of Statues. The casting of statues depends on the due preparation of the pit, the core, the wax, the outer mould, the inferior furnace to melt off the wax, and the upper to fuse the metal.

The pit is a hole dug in a dry place, something deeper than the intended figure, and made according to the prominence of certain parts of it. The inside of the pit is commonly lined with stone or brick; but when the figure is very large, they sometimes work on the ground, and raise a proper fence to resist the impulsion of the melted metal. The inner mould, or core, is a rude mass, to which is given the intended attitude and contours. It is raised on an iron grating strong enough to sustain it, and is strengthened within by several bars of iron. It is generally made either of potters' clay mixed with hair and horse dung, or of plaster of Paris mixed with brick dust. The use of the core is to support the wax and the shell, and lessen the weight of the metal. The iron bars and the core are taken out of the brass figure through an aperture left in it for that purpose, which is soldered up afterwards. It is necessary to leave some of the iron bars of the core, which contribute to the steadiness of the projecting part, within the brass figure. The wax is a representation of the intended statue. If it be a piece of sculpture, the wax should be all from the hand of the sculptor himself, who usually forms it on the core; though it may be wrought separately in cavities, moulded on a model, and afterwards arranged on the ribs of iron over the grating, filling the vacant space in the middle with liquid plaster and brick dust, by which means the inner core is proportioned as the sculptor carries on the wax. When the wax, which is of the intended thickness of the metal, is finished, small waxen tubes perpendicular to it from top to bottom are filled, to serve both as canals for the conveyance of the metal to all parts of the work, and as vent-holes to give passage to the air, which would otherwise occasion great disorder when the hot metal came to encompass it.

The work being brought thus far, must be covered with its shell, which is a kind of crust laid over the wax, and which being of a soft matter, easily receives the impression of every part, which is afterwards communicated to the metal upon its taking the place of the wax, between the shell and the mould. The matter of this outer mould is varied according as different layers are applied. The first is generally a composition of clay, and old white crucibles well ground and sifted, and mixed up with water to the consistence of a colour fit for painting; and it is applied with a pencil, by means of which it is laid on seven or eight times successively. For the second impression horse dung and natural earth are added to the former composition; but for the third impression only horse dung and earth are used. Lastly, the shell is finished by laying on several more impressions of this last matter, made very thick with the hand. The shell, thus finished, is secured by several iron girths bound round it, at about half a foot distant from each other, and fastened at the bottom to the grating under the statue, and at top to a circle of iron where they all terminate.

If the statue be so large that it would not be easy to move the moulds with safety, these must be wrought on the spot where it is to be cast. This is performed in two ways. In the first place, a square hole is dug in the ground, much larger than the mould to be made therein, and its inside is lined with walls of freestone or brick. At the bottom is made a hole of the same materials, with a kind of furnace, having its aperture outwards; and in this is a fire made, to dry the mould, and afterwards melt the wax. Over this furnace is placed the grating, and upon this the mould, formed as above. Lastly, at one of the edges of the square pit is made another large furnace, to melt the metal. In the other way, it is sufficient to work the mould above ground, but with the precaution of a furnace and grating underneath. When finished, four walls are run around it, and by its side a melting furnace is prepared. For the rest, the method is the same in both cases. The mould being finished, and enclosed as described, whether below ground or above it, a moderate

Foundery.

fire is lighted in the furnace under it, and the whole covered with planks, that the wax may melt gently down, and run out at pipes contrived for that purpose at the foot of the mould, which are afterwards exactly closed with earth, as soon as the wax is all carried off. When this is done, the whole is filled up with bricks thrown in at random, and the fire in the furnace augmented, until both the bricks and mould become red hot. The fire is then extinguished, and every thing being cold again, the bricks are taken out, and their place filled up with earth, moistened, and beaten a little at the top of the mould, in order to render it the firmer. These preparatory measures being duly taken, there remains nothing but to melt the metal, and run it into the mould. This is done by means of the furnace above described, which is commonly made in the form of an oven with three apertures, one to put in the wood, another for a vent, and a third to run the metal out at. From this last aperture, which is kept very close whilst the metal is in fusion, a small tube is laid, by which the molten metal is conveyed into a large earthen basin, over the mould, into the bottom of which all the large branches of the jets or casts, which are to convey the metal into the different parts of the mould, are inserted.

These casts or jets are all terminated with a kind of plugs, which are kept close, so that, upon opening the furnace, the brass, which rushes out with violence, may not enter any of them till the bason be full enough of matter to run into them all at once; upon which occasion they pull out the plugs, which are long iron rods with a head at one end, capable of filling the whole diameter of each tube. The whole of the furnace is then opened with a long piece of iron fitted at the end of each pole, and the mould filled in an instant. This completes the work in relation to the casting part; the rest is the sculptor's or carver's business, who, taking the figure out of the mould and earth with which it is encompassed, saws off the jets with which it appears covered over, and finishes it with chisels, gravers, puncheons, and other instruments.

Foundery of Bells. The metal for casting bells, it is to be observed, is different from that employed for casting statues; there being no tin in the statue metal, whereas in the bell metal there is a fifth, and sometimes more.

The dimensions of the core and the wax for bells, especially a chime, are not left to chance, but must be measured upon a scale, or diapason, which gives the height, the aperture, and the thickness, necessary for the several tones required. It is on the wax that the several mouldings and other ornaments and inscriptions, to be represented in relief on the outside of the bell, are formed. The clapper or tongue is not properly part of the bell, but is furnished from other hands. In Europe it is usually of iron, with a large knob at the extremity; and is suspended in the middle of the bell. In China it is only a huge wooden mallet, struck by the hand against the bell; and hence they can have but little of that consonance so much admired in some of our chimes of bells. The Chinese have a method of increasing the sound of their bells, by leaving a hole under the cannon; but this our bell-founders would reckon a defect.

The proportions of our bells differ very much from those of the Chinese. In ours, the modern proportions are, to make the diameter fifteen times the thickness of the brim, and the height twelve times. The parts of a bell are, first, the sounding bow, terminated by an inferior circle, which grows thinner and thinner; secondly, the brim, or that part of a bell whereon the clapper strikes, and which is thicker than the rest; thirdly, the outward sinking of the middle of the bell, or the point under which it grows wider to the brim; fourthly, the waist or furniture, and the part that grows wider and thicker quite to the brim; fifthly, the upper vase, or that part which is above the waist; sixthly, the pallet, which supports the staple of the clapper within; and, seventhly, the bent and hollowed branches of metal uniting with the cannons, to receive the iron keys, by which the bell is hung up to the beam, and which forms its support and counterpoise when rung out.

Foundery || Fountain-tree.

Without entering into the details of the operations, we may state, that the business of bell foundery is reducible to three heads; first, the proportion of a bell; secondly, the forming of the mould; and, thirdly, the melting of the metal.

Foundery of Great Guns and Mortar Pieces. See Cannon-Making.

Letter Foundery, or *Casting of Printing Letters.* See Printing and Type-Making.

FOUNT, or Font, among printers, a set or quantity of characters or letters of each kind, cast by a letter-founder, and sorted. Thus, we say, a founder has cast a fount of pica, of english, and of pearl; meaning that he has cast a set of characters of these kinds.

A complete fount not only includes the running letters, but also large and small capitals, single letters, double letters, points, commas, lines, and numeral characters. See Printing and Type-Making.

FOUNTAIN, a spring or source of water rising out of the earth. Amongst the ancients, fountains were generally esteemed sacred; but some were held to be so in a more particular manner than others. The good effects resulting from cold baths gave springs and rivers this high reputation; for their salutary influence was supposed to proceed from some presiding deity. Particular reasons, however, occasioned some to be held in much greater veneration than others. It was customary to throw little pieces of money into those springs, lakes, or rivers, which were esteemed sacred, in order to render the presiding divinities propitious; as the touch of a naked body was supposed to pollute their hallowed waters. For the phenomena, theory, and origin of fountains or springs, see Spring.

Fountain-Tree, a very extraordinary vegetable, which grows in one of the Canary Islands, and is likewise said to exist in some other places, and which distils water from its leaves in such plenty as to answer all the purposes of the inhabitants who live near it. Of this tree we have the following account in Glasse's *History of the Canary Islands*:—"There are only three fountains of water in the whole island of Hierro, wherein the fountain-tree grows. One of these fountains is called *Acof*, which, in the language of the ancient inhabitants, signifies *river*; a name, however, which does not seem to have been given it on account of its yielding much water, for in that respect it hardly deserves the name of a fountain. More to the northward is another, called *Hapio*; and, in the middle of the island is a spring, yielding a stream about the thickness of a man's finger. This last was discovered in the year 1565, and is called the fountain of Antonio Hernandez. On account of the scarcity of water, the sheep, goats, and swine here do not drink in the summer, but are taught to dig up the roots of fern, and chew them to quench their thirst. The great cattle are watered at those fountains, and at a place where water distils from the leaves of a tree. Many writers have made mention of this famous tree, some in such a manner as to make it appear miraculous; others again deny the existence of any such tree, among whom is Father Feyjoo, a modern Spanish author, in his Teatro Critico. But he, and those who agree with him in this matter, are as much mistaken as those who would make it appear to be miraculous. This is the only island of all the Canaries which I have not been in; but I have sailed with natives of Hierro, who, when questioned about the existence of this tree, answered in the affirmative."

FOUR BOROUGHS' COURT, an ancient Scottish court, so called because composed of delegates from four royal burghs; originally the burghs of Edinburgh, Stirling, Berwick, and Roxburgh; but from the year 1348, when the two last burghs were in the hands of the English, the burghs of Edinburgh, Stirling, Lanark, and Linlithgow. These delegates were assembled yearly at Haddington, before the Lord Chamberlain of Scotland, and formed for appeals from the burgh courts and chamberlain ayres, a court which was to the inhabitants of the burghs what the high court of parliament was to the other inhabitants of the kingdom, the highest and ultimate court of appeal.

In 1405, when the regent, Robert duke of Albany, uncle to King James I., was lord chamberlain, a court of the four burghs was held at Stirling, where it was resolved that deputies from the royal burghs south of the Spey should convene yearly with the four burghs, to consider and conclude on all matters affecting the common weal of all the royal burghs. This convention, though at first assembled with the court of four burghs, does not appear to have ever formed a constituent part of the latter assembly, and it seems also soon to have disregarded both the place and time of its meeting; for in 1487 its constitution was materially improved, representatives from all the royal burghs, " baith south and north," being by a statute of that year appointed to meet in convention yearly at Inverkeithing, " there to commoun and treate upon the weilfare of merchandice, the gude rule and statutes for the common profite of burrowes, and to provide for remeid upon the skaith and injuries sustained within the burrowes."

The chamberlain ayres, which had long been regarded by the nation as a grievance demanding immediate reformation, were thus substantially superseded, and accordingly soon afterwards fell into disuse. The court of four boroughs continued somewhat longer; but on the institution of the court of session, which was vested with a universal civil jurisdiction, its judicial functions were swallowed up, and it likewise expired. The office of lord chamberlain itself also, falling into the hands of the nobility and court favourites, ceased to be exercised; and his place in the convention came to be occupied by the Lord Provost of Edinburgh, who, though not a member, is the constant preses of the convention. The origin of this last circumstance, hitherto, we believe, unexplained by our writers, seems to be this. The convention was, by the statute above mentioned, appointed to meet at Inverkeithing. This, however, it did not long continue to do; but, like the court of four burghs and the other supreme courts of the kingdom, removed to Edinburgh as early as the time of Alexander Lord Home, who was great chamberlain from 1488 to 1517; and as that individual was at one time both lord provost of Edinburgh and great chamberlain of Scotland, and also, as it seems, the last in the latter office who exercised its duties in person, hence, no doubt, arose the practice of the lord provost of Edinburgh being the permanent preses, and the town-clerk of Edinburgh the perpetual clerk, of the convention. This civic parliament has continued till the present time. By stat. 1607, c. 6, letters of horning were allowed to issue on all its acts and decrees betwixt burgh and burgh, and burgesses of free burghs, on a simple charge of ten days.

FOUR SADDLE ISLAND, an island in the Mergui Archipelago, about six miles in circumference, and separated by a narrow strait from the island of St Susannah. Lat. 10. 27. N.

FOUR CRAG'S ISLAND, a low flat island, of a quadrangular figure, on the south-west coast of New Holland. Long. 137. E. Lat. 36. 26. S.

FOURCHEE, or **FOURCHY**, in *Heraldry*, an appellation given to a cross forked at the end. See HERALDRY.

FOURCROY, ANTONY FRANCIS DE, a celebrated chemist and physician, born at Paris on the 15th June 1755, was the son of John Michael de Fourcroy, by his marriage with Jane Laugier. His family had been long established in the capital; several of them had been distinguished at the bar, and Fourcroy de Ramcourt was well known as an engineer of considerable talent, and a member of the Academy of Sciences.

His father was an apothecary attached to the household of the Duke of Orleans, and was a great sufferer by the abolition of places of this kind, which was procured by the corporation of apothecaries, some time before the Revolution. Young Fourcroy was sent to the college of Harcourt, but made no progress in his learning there, and underwent great hardships, from the cruelty of an unjust master. He was afterwards obliged to subsist by his labour in copying, and by taking pupils as a writing master. He was, however, fortunate in the patronage and assistance of Vicq d'Azyr, who had been a friend of his father, and under whose auspices he resolved to study physic; obtaining his support in the mean time by giving his assistance to richer persons than himself in their literary labours, and by a few translations, for which he was very ill paid. When he had gone through the regular course of study, he became a candidate for a gratuitous diploma, upon a foundation established by Dr Diest; but he failed of success, from a party quarrel. His own party, however, which was that of Vicq d'Azyr, indemnified him for the loss, by making a collection to discharge the fees, amounting to about L.250; but the highest degree, that of doctor regent, was still refused him; and he was therefore incapable of holding a professorship under the Parisian faculty of physic. He resolved to apply himself to science as the readiest way of acquiring medical reputation; but he seems to have been little known, at any time of his life, as a practical physician. The determination, however, like that of the countryman in the fable, was still a beneficial one; and though he failed of discovering the golden treasure for which he dug, he profited by the increased fertility of the soil, and by the abundant fruits which it bore him.

In natural history he soon distinguished himself as a pupil worthy of Geoffroy, by an entomological publication; and in anatomy, by his description of the tendons and their sheaths, which appears to have procured his admission into the Academy of Sciences in 1785. He stood at first in the capacity of an anatomist, though he was afterwards removed to the section of chemistry. His favourite pursuit, however, from the beginning, was chemistry; and in this he derived considerable assistance from Bucquet, who was then a professor in great esteem; and having once undertaken to deliver a lecture in his place, on occasion of a temporary indisposition of Bucquet, though wholly unprepared, he found himself capable of speaking for two hours with great fluency, to the delight and astonishment of his audience. The reputation of Bucquet was soon transferred to Fourcroy; and he was enabled, by an advantageous marriage, to purchase the apparatus of his predecessor, and to succeed to his lectures.

In 1784, upon the death of Macquer, then professor of chemistry in the Royal Garden, the Count de Buffon found the claims of Fourcroy so strong, that he thought it right to appoint him to the vacant chair, though no less a chemist than Lavoisier was a rival candidate; the competition not being wholly decided either by talent or by depth of learning, but probably, in a great measure, by the reputation in the art of teaching which Fourcroy had already acquired. His success in this new situation was brilliant and universal; and he continued for twenty-five years to absorb the whole attention of a numerous audience, by his eloquence, and by the perspicuity of his mode of explaining some of the most important novelties that have ever appeared in any age. The science which he taught was then making its most rapid progress. It was then that Bergman and Scheele had introduced into analytical chemistry a precision almost geometrical; that Priestley had discovered the aëriform elements of the animal and vegetable world; that Black and Wilcke had methodised the phenomena of heat; that Cavendish had discovered the composition of water and of the nitric acid; that Monge had repeated and extended his experiments; and that Lavoisier had reduced the whole of chemistry to a uniform system, which, though founded on a generalization somewhat too hasty, has still been of important service to the science, by concentrating the attention of the philosophic reasoner on various classes of phenomena, which could not so easily have been comprehended in one view, without the aid of some such hypothesis. M. de Fourcroy was particularly happy in his tact of perceiving whether or not all his audience were fully in possession of the ideas he wished to communicate to them, and he was never tired of explaining himself, till he was satisfied that he had said enough. His manner was energetic, and such as an Englishman might perhaps have thought pompous and affected; but we must recollect that there is no fixed standard of propriety in matters of taste, and that, as the common conversation of the French is naturally accompanied with more of emphasis and gesture than our own, it is very possible that, without any greater proportional exaggeration than is introduced in similar cases in Great Britain, an actor, a lecturer, or a preacher, may exhibit what to us would appear a caricature, while it only affects his own countrymen as a natural, though impressive, style of public speaking. The chemical amphitheatre of the Public Garden was crowded by students from all countries, and from all quarters of the globe, some prompted to visit Paris by their own love of learning only, some assisted in their pursuits by their respective governments; and it was twice in succession necessary to provide more extensive accommodations for the overflowing numbers that sought for admittance.

M. de Fourcroy's political life, though not unsuccessful, seems to have contributed less materially to his happiness than his scientific career. He was chosen a supplementary member of the National Convention, and entered on the functions of the office in the dreadful period of 1793. He had, however, the wisdom to refrain from employing the eloquence that he possessed under circumstances so dangerous, and he almost entirely confined his exertions to some attempts to soften the cruel tyranny of the times. Darcet was one of the destined victims that he had the good fortune to save; but he soon found it too dangerous to persist in such interferences. M. Cuvier, however, very fully acquits him of any approbation of the judicial murders which were committed, and of any connivance at such proceedings as it might have been possible for him to avert; declaring, that if, upon the strictest inquiry, he could have discovered that there was the least foundation for charging him with having been indifferent to the fate of his great rival Lavoisier, no consideration on earth could have induced him to become the biographer of a person so odious and contemptible. It was at a later period that Fourcroy acquired some little influence as a director of the public instruction; and in this capacity he had great scope for the exertion of his talents, in the re-establishment of the many public institutions connected with science, which the madness of the Revolution had destroyed. The *Ecole de Médécine* was one of the first that was restored; but the name of Médécine seeming to carry with it too much of respect and authority for the levelling spirit of the day, the new institution was at first called *Ecole de Santé*. M. de Fourcroy was also very essentially concerned in the organization of the *Ecole Polytechnique*, as well as of the central schools of the departments, and of the *Normal* schools of Paris; nor was he an indifferent spectator of the establishment of the *Institute*, which was at first intended to be as much immediately subservient to public instruction, as to making known the results of private study. He had also considerable influence in obtaining the adoption of a law calculated greatly to facilitate the formation of a museum of natural history on a magnificent scale. If, in the pursuit of these objects, he sometimes appeared to forget the dignity of language most appropriate to his subject, it must be remembered that he lived in times when the choice of expressions was by no means at the option of the speaker. He was once denounced by the Jacobins, merely for his silence in the assembly; but he excused himself, by pleading the absolute necessity of applying himself to chemical pursuits for the support of his family.

In 1798 his duties as a senator were terminated; but he was made a counsellor of state under the consular government, and again employed in the department of public instruction, with less liberty to pursue his own ideas than before, but with more effectual means of attaining the objects of his appointment. In this capacity he directed, in the course of five years, the establishment of twelve schools of law, and of more than thirty lyceums, afterwards called royal colleges, and three hundred elementary schools; exhibiting, in the performance of this laborious duty, the greatest possible judgment and attention in overcoming the local difficulties which perpetually occurred in the details of the undertaking, and depending on none but himself for the whole of the required arrangements. He conducted himself with great impartiality in his choice of the persons to be employed, though he sometimes found himself obliged to pay a certain degree of deference to the arbitrary power under which he acted, or even to his own political connexions. Remembering the difficulties which he had himself encountered in the early part of his career, he was particularly kind and benevolent in his intercourse with those young men to whom he was the dispenser of public munificence, in admitting them to a gratuitous education.

The great number and extent of M. de Fourcroy's scientific labours may be considered as paramount to a more immediate participation in the discovery of some of the new facts which changed the aspect of the science of chemistry. His ideas were, however, often rather enlarged than profound; and he was not uncommonly somewhat too precipitate in his conclusions; but he was generally methodical in the mode of conducting his researches, and clear in relating their results. His pursuits and projects were sometimes varied a little capriciously, though he prosecuted them all with equal warmth and eloquence. He was too much the slave of public opinion for his own comfort; and even the slightest expression of censure that occurred in private society, or the most unimportant criticism that appeared in a periodical work, became a heavy misfortune to him, and deprived him of his tranquillity for a considerable time. But the desire of universal approbation acted upon him as a strong incentive to continued exertion; and, amongst all his political and official labours, he continued his experiments, his memoirs, and his lectures, with as much eagerness as if they had constituted his whole occupation. His nerves seem ultimately to have suffered by his unremitting application, and he became subject to palpitations, which, as he was well aware, rendered the duration of his life extremely precarious. At last, on the 16th of December 1809, at the age of fifty-four, as he was signing some dispatches, he exclaimed suddenly, "I am dead;" and his words were true. It happened, that on that day his family were about to assemble for the celebration of an anniversary in which they were particularly interested; the assembly actually met, though only to mourn his loss; and their disappointment was rendered the greater, upon the receipt of some distinguished marks of the imperial favour, which arrived too late to be of any use to his spirits or to his health, but which would have been of the more value to him, as he had before been passed over, when some of his colleagues had received considerable gratifications. He had, however, been made a count of the empire, and a commander of the legion of honour, in addition to his various literary and scientific titles; and he must have had the heartfelt satisfaction of reflecting, that he had been of use to the promotion of knowledge by his experiments and his writings; to his country by the public institutions which he had established; and to many deserving individuals by the benefits which he had bestowed on them, without the remorse of having done injury to any one.

He left a son by his first marriage with Mlle. Bettinger, the Count de Fourcroy, an officer of artillery, who was afterwards killed in the campaign of 1813 in Saxony, and a daughter, Mad. Foucaud. By his second marriage with Mad. Belleville, the widow of M. de Wailly, he had no children. His two maiden sisters also survived him, though by no means in a state of affluence; but they received great kindness from his friend and assistant M. Vauquelin. His place at the Institute was very ably filled by M. Thénard; M. Laugier succeeded him at the Museum, and M. Gay Lussac at the Ecole Polytechnique.

The chief of M. de Fourcroy's separate publications are, 1. *Essai sur les Maladies des Artisans*, 12. Paris, 1777, translated from Ramazzini. 2. *Analyse Chimique de l'Eau Sulfureuse d'Enghien*, par Fourcroy et Laporte, 8vo, 1778, applying the recent discoveries on the nature of gases to the contents of this water. 3. *Leçons Elémentaires d'Histoire Naturelle et de Chimie*, 2 vols. 8vo, 1782; 5 vols. 8vo, 1789, 1794; afterwards translated by Nicholson. 4. *Mémoires et Observations de Chimie*, 8vo, 1784; a collection of memoirs intended as a sequel to the elements. Most of these had been read to the academy before the author was a member, and were destined for the *Mémoires des Savans Etrangers*. They relate to the metallic carbonates, to detonations, to tests for water, to combustions in a stream of oxygen, and to the properties of several saline and metallic substances, with a useful introduction on the mode of conducting chemical experiments. 5. An edition of the *Entomologia Parisiensis of Geoffroy*, 2 vols. 12mo, 1780; extracted from Geoffroy's larger work, with the addition of two hundred and fifty new species. 6. *L'Art de connaitre et d'employer les Médicamens dans les Maladies*, 2 vols. 8vo, 1785. 7. *Méthode de Nomenclature Chimique*, par de Morveau, Lavoisier, Berthollet, et De Fourcroy, 8vo, 1787. 8. *Essai sur le Phlogistique et les Acides*, 8vo, 1788; from the English of Kirwan. 9. *La Médécine éclairée par les Sciences Physiques*, 4 vols. 8vo, 1791, 1792; a collection of papers, with some original essays by the editor. 10. *Philosophie Chimique, ou Vérités Fondamentales de la Chimie Moderne*, 1792, 1796, 1800. Reviewed by Deyeux, *Ann. de Chim.* lvi.; a work which has been translated into almost every European language, including modern Greek. 11. *Procédés pour extraire la Soude du Sel Marin*, 4to, 1795. 12. *Système de Connaisances Chimiques*, 10 vols. 8vo, 5 vols. 4to, 1800. This vast collection of chemical information was written from beginning to end in the space of eighteen months, during an interval of leisure from public business. *Rev. Ann. Ch.* xxxvi. xxxvii. Translated by Nicholson. 13. *Tableaux Synoptiques de Chimie*, fol. 1800, 1805. 14. *Abrégé de Chimie, pour l'usage des écoles vétérinaires*. 15. *Chimie pour les Dames*, in the *Bibliothèque des Dames*.

Besides his separate works, M. de Fourcroy was the author of more than a hundred and sixty memoirs, printed in different publications, the principal of which it will be sufficient to enumerate in a very cursory manner, adding a few of Dr Thomson's able criticisms on the respective articles. The most important of his later researches were published jointly in his own name and in that of his pupil Vauquelin; and it is supposed that the processes were generally conducted and often suggested by Vauquelin, but that the investigations were set on foot and directed, and the results described and methodized, with inferences and theoretical reasoning, by Fourcroy.

16. In the *Memoirs of the Academy of Sciences* we find an *Anatomical History of the Tendons and their Mucous Capsules*, 1785, 1786, 1787. 17. *On the Smoking Oil of Vitriol of Saxony, and the Concrete Salt obtained from it*, 1785; modifications of the sulphurous acid. 18. *On Hepatic Gas*, 1786. 19. *Report on a Sand from Peru containing Copper*. 20. *On Azote, and its production in animals*, 1787. 21. *On detecting Lead in Wines*, 1787. 22. *On Combustions in the Oxymuriatic Acid*, 1788. 23. *On Metals precipitated by Ammonia*, 1788. 24. *Experiments on Animal Substances, made at the Lyceum*, 1789. 25. *On a Liver changed by putrefaction*, 1789. 26. *On the Colours derived by Vegetables from Oxygen*, 1789. 27. *On an Ore of Lead from Roziers*, 1789. 28. *On the Sulfate of Mercury, and on Triple Ammoniacal Salts*, 1790. 29. *On the Formation of the Nitric Acid by the Action of the Oxyd of Mercury on Ammonia*, 1790. 30. *On the Combustion of Hydrogen in close vessels*, by Fourcroy, Vauquelin, and Séguin, 1790. 31. *On Barita and Strontia*, Mém. Inst. vol. ii. 1797. 32. *On Phosphate of Lime and on Phosphorus*, ib. 33. *On the Urinary Secretion in Horses and in the Human Subject*, ib. 34–36. *On Urinary Calculi, with two more Memoirs on the Secretion*, iv. 1803. 37. *On the Nitrous Oxyd*, by Fourcroy, Vauquelin, and Thénard, vi. 1806. 38. *On Cow's Milk*, ib. 39. *On the Guano, used as a Manure in the South Sea Islands*, ib. 40. *On Tabasheer*, ib. 41. *On the Chemical Nature of Carious Wheat*, ib.; the change is supposed to depend on an alteration and depravation of the gluten. 42. *On a Detonating Substance obtained from Indigo*, ib. 43. *On Animal Substances treated by Nitric Acid*, ib. 44. 45. *Two Memoirs on Crude Platina and a new Metal found with it*. 46. *On the effects of Germination and Fermentation on Corn and Pulse*, vii. 1801. 47. In the *Memoirs of the Royal Society of Medicine for* 1782–83–84, Par. 1787, we find a valuable memoir *On the Muriate of Lime*, p. 267, which the author seems to have been one of the first to introduce in such cases as had usually been benefited by sea water. 48. *On Morbid Changes in some of the Animal Fluids*, p. 488. 49. *On the Nature of Muscular Fibres, and on the Seat of Irritability;* showing the analogy of muscular fibre to the coagulable lymph of the blood, and observing that Bordeu had very properly called the blood a fluid muscle.

Many of these earlier papers have also been printed in the *Annales de Chimie*, but they are sometimes altered, and they are mixed with others which are original. 50. *On Azote* (20), vol. i. (1789). This memoir exhibits no very favourable specimen of the author's accuracy; for he asserts in it that pure azote turns vegetable blues to green, and that it may be obtained by means of a low heat, from the oxide of manganese. 51. *On the Gas in the Air Vessels of the Carp*. 52. *On a Morbid Change in the Blood*, ib.; exuding from the face. 53. *On detecting Lead in*

Wine (21), ib. 54. 55. *On two Ores of Lead*, ii.; containing the arseniate and the phosphate. 56. *On the action of Oxyds on Ammonia*, ib.; particularly those of manganese, mercury, and tin. 57. *On the Salts of Magnesia*, ib. 58. *On a Change in the Liver after Death* (25), iii. 59. *On Biliary Calculi*, ib.; describing the adipocere of these substances. 60. *On the Albumen of Vegetables*, ib.; more properly distinguished by Proust under the name of gluten. 61. *On the Carbonate of Barita of Alston Moor*, iv. 62. *On the Medical Properties of Oxygen*, ib. 63. *On the Triple Salts of Ammonia and Magnesia*, ib.; an elaborate and interesting paper. 34. *On Combustions in Oxymuriatic Acid Gas*, ib. 65. *On the effect of Oxygen in colouring Vegetables, and on the preparation of Solid Pigments*, v. 66. *On the Changes observed in the Cemetery of the Innocents*, ib. Fourcroy had been appointed, together with Thouret, to superintend the removal of these remains to a remoter spot, and observed that the muscular parts were often slowly changed into a substance nearly resembling spermaceti. 67. *On a Black Sand from St Domingo*, vi. 68. *On the Water of Enghein*, (2), ib. 69. *Discoveries in Animal and Vegetable Chemistry*, ib. 70. *On the Formation of the Nitric Acid from the Action of the Oxyd of Mercury on Ammonia*, (29), ib. 71. *On the Culture of Cloves in the Isle of Bourbon*, vii. 72. *Experiments on Animal Substances, made at the Lyceum in* 1790, (24), ib. 73. *Second Memoir on the Substances found in the Cemetery.* 74. *On the Cinchona of St Domingo*, viii. x.; a very valuable analysis of a species of bark officially referred to his examination. 75. *On the Combustion of Hydrogen*, (30), viii. 76. *Report on Loyser's Art de la Verrerie*, ix. 77. *On Bell Metal*, ib. The principal object of this paper is to discover a ready mode of converting the spoils of the churches into copper coin, by fully oxidating a part of the alloy, and fusing the remainder with it; the whole of the tin becomes oxidated, and the copper is melted out in a state of purity. 78. *On Tears and Mucus*, x.; a valuable investigation of the nature of the substances most generally diffused in the animal fluids. 79. *On the Sulfate of Mercury, and its combination with Ammonia*, ib.; a paper containing several new facts, though mixed with some inconclusive reasoning. 80. *On the Refinement of Saltpetre*, xi. 81. *On the Juice which furnishes Elastic Gum*, ib. 82. *Note on the Decomposition of the Carbonic Acid Gas, effected by Mr Tennant*, xii. 83. *On Triple Salts*, xiii. 84. *On Animal Concretions*, from the *Dictionnaire Encyclopédique.* 85. *On the Brain*, xvi. 86. *Report on some Artificial Pencils*, xx. 87. *Extract of a Memoir on Hydrocarbonous Gas, and on the supposed Combustion of Azote*, xxi.; showing that though phosphorus is soluble in azote, it is only so far burned in it as some particles of oxygen happen to be present. 88. *On Detonations by Percussion*, ib. 89. *Extract of a Memoir of Proust on Odoriferous Substances*, ib.: M. de Fourcroy proved the non-existence of any separate principle deserving the name of aroma, and showed that odorous substances in general were volatilized without any change of their nature or separation of their parts. 90. *On obtaining Pure Barita*, ib.; an elegant and effectual process. 91. *On the Union of Chemistry with Pharmacy*, ib. 92. *On Vitality, and on Humboldt's Experiments*, xxii. 93. *On the Action of the Sulfuric Acid on Vegetable and Animal Substances*, xxiii. 94. *On the Formation of the Sulfuric Ether*, ib. This paper seems to make it probable that the attraction of the acid for water tends to facilitate the formation of the ether in this instance, though the same theory cannot be applied to the action of the other acids on alcohol. 95. *On the Sulfurous Acid*, xxiv. 96. *Report on some Colours for Porcelain*, xxv. 97. *Letter to Humboldt on the Chemistry of Life*, xxvii. 98. *Examination of Dr Pearson's Experiments on Calculi*, ib.; with a general request to medical men, soliciting the communication of specimens. 99. *On Pneumatic Medicine*, xxviii. 100. *On the Experiments of Mayow*, from the *Dictionnaire Encyclopédique*, xxix. 101. *Novelties from Egypt*, ib. 102. *On Congelation by Artificial Cold*, ib. 102. *Letter to Giobert on Calculi*, xxx. 103. *Notice of Venténat's Vegetable System*, ib. This botanist has given to an elegant genus of plants the name of Furcroea, in compliment to the merits of our author in natural history. 104. *On the Chemical and Medical History of the Urinary Secretion*, xxxi. xxxii.; finding some of the peculiar substances which occur in the human subject to be identical with some of the contents of the excretions of birds, though they are wanting in the same fluid formed by quadrupeds. M. de Fourcroy had ascertained that some of the calculi found in animals were capable of being dissolved by a weak solution of vinegar, and he had conceived some hopes that the observation might be applied with advantage to similar diseases in the human subject. His investigations respecting calculi, however, notwithstanding their importance, were in a great measure anticipated by the acute penetration of our celebrated countryman Dr Wollaston, though his paper is not mentioned by M. de Fourcroy. 105. *Notice of the Chimie Optomathique*, xxxi. 106. *Account of a Memoir of Fabroni on Fermentation and on Ether*, ib. 107. *Chemical Novelties*, xxxii. 108. *Report on Paul's Artificial Waters*, xxxiii. 109. *On Dabit's Ether*, xxxiv. 110. *On the Identity of the Three Empyreumatic Acids with the Acetic*, xxxv.; suggesting that they might be substituted for it in some economical processes. 111. *Galvanic Experiments*, xxxix.; by Fourcroy, Vauquelin, and Thénard. 112. *Note in answer to Proust*, xlii. 113. *Remarks on a Memoir of the Dutch Chemists on the Carbonic Oxide*, xliii. 114. *On a New Phosphate found in the Bones*, xlvii.; that of magnesia, not before observed. 115. *Extract of a Memoir on Platina*, xlviii. 116. 117. *Two Memoirs on Crude Platina, and on a Metal found with it*, xlix. l. These researches were less successful than those of Mr Tennant, Dr Wollaston, and Mr Descorils, which were completed about the same period. 118. *Extract from Izarn's Manual of Galvanism*, l. 119. *On the Alumina of Saxony*, lii. 120. *On a Fluid found in the Caoutchouc of the Castilloya Elastica*, lv. 121. *On a Detonating Substance formed by the Action of the Nitric Acid on Indigo and Animal Matters*, lv.; the investigations relating to indigo have since been carried further by Mr Hatchett. 122. *On the Products of Animal Substances treated with the Nitric Acid*, lvi.; yielding more azote as they are more highly animalized. 123. *On the Guano*, (39), lvi. 124. *Experiments on Ivory, Recent and Fossil, and on the Enamel of the Teeth, in search of the Fluoric Acid*, lvii.; these experiments were not completely successful, though Morichini had detected the fluoric acid in the teeth before that time, and Berzelius has found it still more recently.

M. de Fourcroy was for some years the editor of the *Journal des Pharmaciens;* he first suggested the idea of the publication of the *Annales du Muséum d'Histoire Naturelle*, and contributed several valuable papers to it, as well as to the *Journal de l'Ecole Polytechnique*, and to the *Magazin Encyclopédique.* He was also the author of some very voluminous articles in the chemical part of the *Encyclopédie Methodique;* but the fabric of his celebrity is principally founded on the works which have already been enumerated, and which are better known to the public.

(Palissot de Beauvois, *Eloge Historique*, Par. 1810; Cuvier, *Eloge*, M. Inst. A. Math. 1810, and in Biographie Universelle, xv. 8. Par. 1816; Thomson's *Annals*, i. May

1818, p. 321; Aikin's *General Biography*, vol. x. 4to, Lond. 1815.) (L. L.)

FOURMONT, Stephen, professor of the Arabic and Chinese languages, and one of the most learned men of his time, was born at Herbelai, near Saint Denis, about four leagues from Paris, in 1683. He studied in Mazarin College, and afterwards in the Seminary of Thirty-three. He was at length appointed professor of Arabic in the Royal College, and admitted a member of the Academy of Inscriptions. In 1738 he was chosen a member of the Royal Society of London, and in 1741 a member of that of Berlin. He was often consulted by the Duke of Orleans, first prince of the blood, who had a particular esteem for him, and made him one of his secretaries. He was the author of many learned works, the most important of which are, 1. *Racines de la Langue Latine mises en vers François*, Paris, 1706, in 12mo; 2. *Réflexions Critiques sur les Histoires des Anciens Peuples*, Paris, 1735, in 2 vols. 4to; 3. *Meditationes Sinicæ*, 1737, in folio; 4. *Grammatica Sinica* (Chinese Grammar), 1742; and, 5. Several Dissertations printed in the *Mémoires de l'Acad. des Inscriptions.* Fourmont died at Paris on the 18th December 1745, at the age of sixty-two. He must not be confounded with *Michel Fourmont*, his youngest brother, who was professor of the Syriac language in the Royal College, and a member of the Academy of Inscriptions, and who died in 1746.

FOURNESS, in Loynsdale, Lancashire, is a tract between the Kent, the Leven, and the Dudden sands, which runs north parallel with the west sides of Cumberland and Westmoreland, and on the south runs out into the sea as a promontory. Here, as Mr Camden expresses it, "the sea, as if enraged at it, lashes it more furiously, and in high tides has even devoured the shore, and made three large bays; viz. Kentsand, into which the river Ken empties itself; Levensand and Duddensand, between which the land projects in such a manner that it has its name hence; Foreness and Foreland, signifying the same with us as *promontorium anterius* in Latin." Bishop Gibson, however, derives the name of *Fourness*, or *Furness*, from the numerous furnaces that were there anciently, the rents and services of which, called *Bloomsmithy rents*, are still paid. This whole tract, except on the coast, rises in high hills and vast piles of rocks called *Fourness-Fells*, amongst which the Britons found a secure retreat, trusting to these natural fortresses, though nothing was inaccessible to the victorious Saxons; for we find the Britons settled here 228 years after the arrival of the Saxons; because at that time Egfrid king of Northumberland gave St Cuthbert the land called *Carthmell*, and all the Britons in it, as is related in his life. In these mountainous parts are found quarries of a fine durable blue slate, which is made use of to cover buildings in this and many other parts of the kingdom.

FOU-TCHANG, a city of China, in the province of Pe-tche-li, situated on the banks of the grand canal. It is an ancient city, but the gates at the extremities are in a state of decay. It has a bridge of great antiquity, consisting of four large arches and three smaller ones, secured by parapets; the whole of which is crumbling down.

FOU-TCHEOU, a city of China, of the first rank, which is celebrated for a magnificent bridge built of stone, with 100 arches, and a double balustrade along the whole length. The city is governed by a viceroy, and has nine others under its jurisdiction. It is the residence of many literati, and has a good harbour. Fou-tcheou is 870 miles south of Pekin. Long. 119. 4. E. Lat. 20. 4. N. This is also the name of a city of the third rank, which was almost ruined by an invasion of the Tartars. It is 735 miles south of Pekin.

FOWEY, a market-town and seaport of the county of Cornwall, in the hundred of Powder, 239 miles from London. The harbour, deemed the best on that part of the coast, is formed by the river Fowey, which there empties itself into the channel. There is space and depth of water for 1000 vessels. It has, however, but little trade, except that which in the few months of summer consists in the catching of pilchards, which, though a casual, is sometimes a source of great profit. The mouth of the river is defended by several forts of various dates. It is governed by a mayor, recorder, and eight aldermen, and returns two members to the House of Commons, chosen by the inhabitant householders. The population amounted in 1801 to 1155, in 1811 to 1457, in 1821 to 1455, and in 1831 to 1767.

FOWL, among zoologists, denotes the larger sorts of birds, whether domestic or wild; such as geese, pheasants, partridges, turkeys, ducks, and the like.

FOWLING, the art of catching birds by means of birdlime, decoys, and other devices, or the killing of them by the gun.

Fowling is also used for the pursuing and taking birds with hawks, more properly called falconry or hawking.

FOX, in *Zoology*. See Mammalia.

Fox, *John*, the martyrologist, was born at Boston in Lincolnshire, in the year 1517. At the age of sixteen he was entered a student of Brazen-Nose College in Oxford; and in 1543 he took his degree of master of arts, and was chosen fellow of Magdalen College. He discovered an early genius for poetry, and, conformably to the taste of his age, wrote several Latin comedies upon subjects taken from Scripture. Of these, one still remains, entitled *De Christo Triumphante*, printed at London in 1551, and at Bâle in 1556, 8vo, and reprinted in 1672. But having forsaken the muses, he applied himself with great assiduity to the study of theology, including church history; and having manifested an inclination, which he took no pains to conceal, for the doctrines of the reformation, he was, in the year 1545, expelled from his college as a heretic, happy, it is said, to have fared no worse. He had lost his father early in life, and, as his mother had married again, his stepfather availed himself of this occurrence to retain the whole of his patrimony, knowing that Fox would not venture to sue him for restitution. This rascality on the part of his mother's husband reduced him to the greatest distress; but he soon afterwards found an asylum in the house of Sir Thomas Lucy, Warwickshire, who employed him as tutor to his children. When this engagement expired, Fox, who had in the meanwhile married the daughter of a citizen of Coventry, proceeded to London; but finding no immediate means of subsistence, he was again reduced to absolute want. Relief, however, at length came, and in a manner which is described as almost miraculous. As he was one day sitting in St Paul's church, emaciated with hunger, a stranger accosted him familiarly, and, bidding him be of good cheer, put a sum of money into his hand; telling him, at the same time, that new hopes were at hand. And, in fact, he was, three days thereafter, received into the family of the Duchess of Richmond, as tutor to the Earl of Surrey's children, who, upon their father being sent to the Tower, were committed to her care. In this family he lived at Ryegate in Surrey, during the latter part of the reign of Henry VIII., the entire reign of Edward VI., and part of that of Queen Mary; but he could never discover the generous person who had at once relieved his distress and predicted his good fortune. At length, however, being persecuted by his implacable enemy Bishop Gardiner, he was obliged to seek refuge abroad; and he selected as the place of his retreat Basil in Switzerland, where he subsisted by correcting for the press. But on the death of Queen Mary he returned to England, where he was graciously received by his former pupil the Duke of Norfolk, who retained him in his family as long as he lived, and bequeathed him a pension at his death, which took place in 1563. Mr Secretary Cecil also bestowed on him a rectory near Salisbury; and, in point of fact, he might have obtained considerable church preferment, had it not been for his unwillingness to subscribe to the canons. He died in the year 1587, in the seventieth year of his age, and was buried in the chancel of St Giles's, Cripplegate. Fox was a man of great industry, and considerable learning; a zealous, but not a violent reformer; a nonconformist, but not an enemy to the Church of England. The most celebrated of his works is that which is entitled *Acts and Monuments of the Church*, and commonly called *Martyrology*, containing a history of the troubles in the church of Rome since the tenth century, particularly in England and Scotland. It was published at London, 1563, in folio, but afterwards augmented, and printed for the fourth time in 1583, two vols. folio, and in 1632, three vols. folio. He relates in detail the history of the martyrs of the Protestant religion, but embellishes his narrative with so many marvellous circumstances, that his enemies, it must be confessed, had some reason in applying to it the name of Legend. The Catholics, in particular, reproached him with passion and with grossness; and, what was far more serious, accused him of having often altered the truth in order to swell the number of martyrs to his creed. Nor can it be denied that, in the first edition, he had enrolled amongst the number of those who had sealed their testimony with their blood, persons still living, and who remonstrated against the honour intended for them. But notwithstanding all these and many other objections, some of which are undoubtedly well founded, the *Martyrology* met with prodigious success in England, where, amidst all the changes which have taken place in taste and opinion, it still maintains its ground. The other writings of Fox, which were very numerous, consist of works on theology, and particularly controversy; and some of his letters which have been preserved reflect honour on his character as a man of sense and humanity.

Fox, *George*, the founder of the sect of Quakers, was born at Drayton, Leicestershire, in the year 1624. His father, a zealous Presbyterian, was a weaver. Young Fox, from his earliest years, showed uncommon gravity, and participated in none of the diversions natural to his age; he courted solitude, and when he spoke it was in a melancholy tone. His parents were unable to give him any education beyond reading and writing, but they early inspired him with sentiments of religion and virtue. Fox was at first placed with a wool-merchant, and sent to tend sheep in the woods; a circumstance which seems to have confirmed his inclination for a solitary and contemplative life. He was then put as an apprentice to a shoemaker at Nottingham; and from the accounts of the times we learn, that as he wrought at his trade, he used to meditate much on the Scriptures, which, with his solitary course of life, improving his natural melancholy, induced him at length to fancy himself inspired; and in consequence he set up as a preacher. He proposed but few articles of faith, insisting chiefly on moral virtue, mutual charity, the love of God, and a deep attention to the inward motions and secret operations of the Spirit; he required a plain, simple worship, and a religion without ceremonies, making it a principal point to wait in profound silence for the directions of the Holy Spirit. Fox met with much rough treatment on account of his zeal, was often imprisoned, and several times in danger of being put to death. But, in spite of all discouragements, his sect, which received the name of *Quakers*, prevailed, and many considerable men were led to join them; amongst whom were Barclay and Penn. Fox died on the 16th of January 1690. He was comparatively an uneducated man, as we have already seen; but he possessed in an eminent degree the talent of persuasion, since, although born in an inferior grade of society, and devoid of any but the simplest instruction, he succeeded in recommending his doctrine to men of a superior rank in society. It was undoubtedly owing to this circumstance that the society of Quakers, or, as they call themselves, Friends, was enabled to outlast so many other sects, founded by enthusiasts, which have generally disappeared immediately after the death of their authors; whereas Quakerism acquired every day new force, and the laws which at first persecuted, ended by tolerating, and even protecting it. Fox, however, only laid the foundation; it was reserved for Barclay and Penn to raise the superstructure. The writings of Fox have been collected in three volumes folio; the first containing his Journal, which is eminently curious; the second, his Correspondence; and the third, all that he has written on his Doctrine. Some persons have indeed pretended that he is not really the author of these different productions; but his followers, on the other hand, maintain that whatever is most admirable in this collection really proceeded from the pen of their patriarch.

FOX, Charles James, a celebrated statesman and orator, was third son of the Right Honourable Henry Fox, afterwards Lord Holland, and of Lady Georgina Caroline Fox, eldest daughter of Charles, second Duke of Richmond. He was born on the 24th January 1749.

Mr Fox received the first rudiments of his education in a private school of some celebrity, kept by a Mr Pampelune at Wandsworth. In 1758 he was sent to Eton, where he gave early promise of future eminence. In the beginning of summer 1763 the mistaken indulgence of his father carried him first to Paris, and then to Spa. After wasting idly three months abroad, he was sent home to England, and at his own desire he went back to Eton. He had left school a boy; he returned to it with all the follies and fopperies of a young man. At Spa he had been initiated in play; and his father, whose fondness for him was excessive, had encouraged him in a propensity which was the source of much future unhappiness to both.

In the autumn of 1764 he was removed from Eton and sent to Oxford, where he was placed at Hertford College, under the tuition of Dr Newcome, afterwards primate of Ireland. At Oxford as well as at Eton he distinguished himself not less by his powers of application than by the quickness and superiority of his parts. The following letter, which he preserved with care, and used to show with triumph when reproached for idleness, is a curious document of his diligence in study while he was at college. "You judge rightly," says Dr Newcome in a letter to his pupil, "in thinking that I should be much surprised by the information which you were so obliging as to give me. But, on reflection, I think you have done well to change the scene in such a manner, and I feel myself inclined to envy you the power of doing it. Application like yours requires some intermission; and you are the only person with whom I have ever had connection to whom I could say this. I expect that you will return with much keenness for Greek, and for lines and angles. As to trigonometry, it is matter of entire indifference to the other geometricians of the college (who will probably continue some time here), whether they proceed to other branches of mathematics immediately, or wait a term or two longer. You need not, therefore, interrupt your amusements with severe studies; for it is wholly unnecessary to take a step onwards without you, and therefore we shall stop till we have the pleasure of your company. All your acquaintances here whom I know are well, but not much happier for your absence." This letter was probably written in spring 1765, when Mr Fox made a second excursion to Paris with his mother.

In autumn 1766 he quitted Oxford, and accompanied his father and mother to the south of Europe, where Lord Holland had been advised to pass the winter on account of his health. He remained with them at Naples during the winter, and not finding a good Italian master there, taught himself that language. In the following spring he attended them as far as Turin in their way to England, and then went to Genoa to meet Lord Fitzwilliam, with whom and Mr Uvedale Price he spent the summer in Italy, chiefly in Tuscany. In the beginning of winter he rejoined his father and mother at Paris, and accompanied them to Nice, where he passed with them the winter of 1767–68. It was during this long residence in Italy that he contracted his strong partiality for Italian literature. In a letter to Mr Fitzpatrick, written from Florence in September 1767, he conjures him to learn Italian as fast as he can, if it were only to read Ariosto. "There is more good poetry in Italian than in all other languages I understand put together." He appears to have indulged freely at this period in all the pleasures natural to his time of life, but never to have intermitted entirely his application to study. *Je travaille toujours le matin*, he says, in another letter written from Nice. Acting plays was also at this time one of his favourite passions, though he confesses that the last time he acted he fell far short of his own expectations; "but then," he adds, "my expectations, it must be confessed, were very high." In the course of this journey he made a visit to Voltaire at Fernay, in company with Mr Price.

He did not return to England till August 1768; and having been elected one of the burgesses for Midhurst in his absence, he took his seat in the ensuing session, and made his first speech in the House of Commons on the 15th of April 1769, in support of the decision in favour of Colonel Luttrel, on the famous Middlesex election. He spoke, says Horace Walpole, with insolence, but with infinite superiority of parts.

Lord Holland, father to Mr Fox, had begun his political career as an adherent of Sir Robert Walpole, and continued ever after one of the steadiest friends and warmest admirers of that great statesman. The treachery of the Pelhams to his patron excited an early prejudice in his mind against all the members of that family; and the falseness, folly, and fickleness of the Duke of Newcastle added contempt and distrust to his dislike. After a long rivalship with Mr Pitt, he was finally driven from the cabinet by a coalition of the Pitt and Newcastle parties, and reduced to the subordinate though lucrative employment of paymaster of the forces. In this situation he was found by Lord Bute at the conclusion of the war, and recommended to the king as the only person in the House of Commons who had courage and ability to defend the peace against Mr Pitt and the Newcastle party. It was with great difficulty he was prevailed on by his majesty to undertake this office, but when engaged in it, he performed it most successfully. For his services on this occasion he was rewarded with a peerage; but the part he had taken estranged him for ever from his old friends the Dukes of Cumberland and Devonshire, and other leaders of the Whig party. It was at this period that his son Charles received his first political impressions; and there is still extant a copy of French verses written by him in 1764, in praise of Lord Bute, and full of invective against Mr Pitt. When brought into parliament, he was, therefore, in the first instance, connected with the Duke of Grafton's administration, which, though originally formed under the auspices of Lord Chatham, had been gradually sinking into a mere court party.

Mr Fox was not of age when returned to parliament, and probably for that reason, after his first speech, he took little part in public debate till January 1770. During this interval he made another excursion to the Continent, where he is chiefly taken notice of for his losses at play. He had, as already mentioned, acquired a passion for play as early as his first journey to Spa; and for many years afterwards, when not engaged in active political business, play and Newmarket were his chief avocations. His losses were such as early to embarrass, and finally to ruin, his private fortune; but so great a hold had these pursuits taken of his mind, that, till the payment of his debts in 1794, he could never prevail on himself to renounce them entirely. From that moment he gave them up for ever.

In February 1770 he was rewarded for his support of government with the place of junior lord of the admiralty, which he retained for two years, and resigned on the 20th of February 1772, partly in consequence of some slight offence he had received from Lord North, and partly because he had resolved to oppose the royal marriage bill, "which, *in place*," he says, "I should be ashamed of doing;" but he had no thoughts, he adds, "of going into opposition." He had an immediate and satisfactory explanation with Lord North; but, to punish him for his speech against the royal marriage act, which was a measure entirely the king's own, he was suffered to remain a considerable time out of office. At length, in January 1773, he was made one of the lords of the treasury, a situation he continued to fill till his memorable quarrel with Lord North in the following year.

Some gross and scandalous reflections upon the speaker of the House of Commons, written by the celebrated Horne Tooke, having appeared in the Public Advertiser, Mr Woodfall, the printer of that newspaper, was called to the bar of the house, and having there confessed himself publisher of the libel, he was declared guilty of a breach of privilege; on which Mr Herbert moved that he should be taken into the custody of the serjeant-at-arms. The house, unwilling to engage in a fresh contest with the press and the city, were disposed to acquiesce in this motion; but Mr Fox, thinking the punishment inadequate to the offence, without consulting Lord North, moved, as an amendment, that Mr Woodfall should be committed to Newgate. Lord North found himself compelled by this motion to resist Mr Herbert's proposition; but though he substituted the Gatehouse for Newgate, as a less objectionable place of confinement, he was left in a minority on the division, the original motion being carried by a great majority. Incensed at this disgrace, and determined to punish his youthful colleague for his temerity, he had a new commission of the treasury made out a few days afterwards, in which the name of Mr Fox was omitted. This happened in February 1774.

Long before his breach with Lord North, Mr Fox had formed an intimate acquaintance with Mr Burke, one of the leading members of the Whig or Rockingham party in the House of Commons; and to the friendship he contracted with that gentleman may, in a great measure, be attributed the decided change in his political character and opinions, which commenced at this time. He had been brought up by his father in the maxims and principles of Sir Robert Walpole; and from this education he derived the love of peace, the good-humoured spirit of conciliation, and ardent attachment to civil and religious liberty, which were afterwards the most conspicuous features of his public character, and are certainly the chief merits of the Walpole school. But the tone and character of Sir Robert Walpole's policy, though suitable, and perhaps necessary, for the times in which he lived, was no longer adapted to the state of the country. When the Jacobites renounced their idol without changing their creed, and transferred to the house of Brunswick the same allegiance which they had borne to the Stuarts, the weapons which Sir Robert had employed to preserve the constitution became, in the hands of its enemies, instruments of its destruction. Mr Burke was the first to perceive, or at least the first to explain, the change that had taken place in our internal government, and the first to point out a plan of systematic opposition in parliament, as the only means of preventing, or at least of retarding, what Mr Hume has called the *euthanasia* of English liberty. In Mr Fox he found a pupil ready to receive his lessons, and prepared by character and turn of mind to act upon them with fortitude and perseverance. From Mr Burke's example and instructions Mr Fox caught more elevated notions of public principle than had animated the successors of Sir Robert Walpole; and from the writings and conversation of the same great man he learned the necessity of party connections in a mixed government like ours, to counteract the influence of government, and preserve a due balance of power between the crown and the people. The American war roused all the energies of his mind. The discussions to which it gave rise involved all the first principles of free government. The vicissitudes of the contest tried the firmness of its opponents. Its duration exercised their perseverance. Its magnitude and the dangers of the country called forth their powers. The progress of Mr Fox was steady and uninterrupted. So early as the beginning of 1775, we are told by Gibbon that "he discovered powers for regular debate, which neither his friends hoped nor his enemies dreaded."

But, notwithstanding the brilliancy of his talents and the reputation he acquired in the House of Commons, the levity and want of decorum of his private life, the dissipation in which he indulged, and the embarrassments in which he was involved, prevented him, for some years, from obtaining the weight and consideration with opposition, due to his extraordinary abilities and exertions. So late as the beginning of 1778 he was under no engagements with any set of men; but, though not absolutely engaged in party connections with the Whigs, he had determined on no account to abandon their principles; and from a cool consideration of his own character, and a just conception of the prevailing sentiments of the country, he had already fully made up his mind to the fate that ultimately awaited him. "People flatter me," he says in a letter to Mr Fitzpatrick, written in 1778, "that I continue to gain rather than to lose character as an orator; and I am so convinced this is all I ever shall gain (unless I chuse to be one of the meanest of men), that I never think of any other object of ambition. I am certainly ambitious by nature, but I have, or think I have, totally subdued that passion. I have still as much vanity as ever, which is a happier passion by far, because great reputation, I think, I may acquire and keep; great situations I never can acquire, nor, if acquired, keep, without making sacrifices that I will never make. If I am wrong, and more sanguine people right, *tant mieux*, and I shall be as happy as they can be; but if I am right, I am sure I shall be happier for having made up my mind to my situation." He expresses great joy at the prospect of Fitzpatrick's return, who he knew would be of his opinion in certain emergencies that might arise. "I shall be told by prudent friends that I am under no sort of engagements to any set of men. I certainly am not; but there are many cases where there is no engagement, and yet it is dishonourable not to act as if there was one. But even suppose it were quite honourable, is it possible to be happy in acting with people of whom one has the worst opinion, and being on a cold footing (which must be the case) with all those whom one loves best, and with whom one passes one's life?" With these sentiments it is not to be wondered at that he rejected overtures made to him by Lord Weymouth, in summer 1778, to join administration; nor, with his powerful talents and unremitted exertions, the inflexible steadiness of his public conduct, and the unexampled force and vehemence of his eloquence, that he gradually acquired the perfect confidence of the Whigs, and came at length to be considered as the leading member of the Rockingham party in the House of Commons. It ought to be recorded to the credit of Mr Burke, that he witnessed with pleasure, unmixed with envy, the progress and elevation of his pupil, and cheerfully resigned to him the station he had so long himself occupied in the party.

The day of triumph at length arrived. A resolution against the further prosecution of the American war was carried in the House of Common. Ministers still lingered in office, but the fears of a direct vote of censure compelled them to resign. The king, whose pertinacity in support of his favourite principles of government had been the chief if not the sole cause of the apparent reluctance of his ministers to retire from office, was compelled at length to yield to the wishes of his Commons; but in the very act of forming a new administration, he contrived to sow the seeds of disunion in its bosom. The opposition to the American war had been composed of two parties, united in their disapprobation of that contest, but disagreeing on many other points of external as well as of internal policy; both calling themselves Whigs, but Whigs of different schools; the one consisting of the old Whig connection, formed and educated in the principles of Mr Burke; the other composed of the friends and followers of Lord Chatham. At the head of the first was the Marquis of Rockingham, whilst the leader of the second was the Earl of Shelburne. His majesty began by sounding Lord Rockingham, through the chancellor. The demands of Lord Rockingham were, to have full power to recognise the independence of America, and authority to bring forward, as ministerial measures in parliament, bills for reducing the influence of the crown, by abolishing offices, excluding contractors from the House of Commons, and depriving revenue officers of their votes at elections; and, with respect to reform in the representation, or limitation of the duration of parliament, he declined to lay himself under restrictions. After taking time to consider this answer, his majesty sent for Lord Shelburne, and had a conference with him at Buckingham house. Two days afterwards he sent for him again, and offered him the treasury, which his Lordship declined, saying that no administration suited to the present emergency could be formed unless Lord Rockingham was at the head of it; on which the king desired him to go to Lord Rockingham with an offer of the treasury, and to add, that he had full powers from his majesty to treat both with respect to men and measures, with one reservation only, that he should himself be one of the secretaries of state. The first impulse of Lord Rockingham was to decline this offer, upon the ground, that if it was the king's intention to place him at the head of the treasury, his majesty could have no fit objections to conversing with him on the arrangement of the administration; but his friends persuaded him to overlook that objection, lest his refusal should be ascribed to pique or jealousy, at a moment when the public was extremely impatient for the formation of a government. Many fatal consequences ensued from the negotiation taking this course and passing through the hands of Lord Shelburne. No direct communication took place between the king and the Rockingham party, who were to compose the majority of the cabinet, with respect to the measures to be pursued, till after the administration had been formed. Lord Thurlow, a decided partisan of the old system, and an enemy to every species of reform, was retained as lord chancellor; Mr Dunning having been prevailed upon by his friend Lord Shelburne to waive his pretensions to that office. When this arrangement was communicated to Mr Fox, he told Lord Shelburne plainly, "that he perceived the administration was to consist of two parts, one belonging to the king, the other to the public." But the worst effect of all was the impression left on the mind of Lord Shelburne, that he alone possessed the confidence of his sovereign, to the exclusion of his colleagues. This persuasion bred distractions in the cabinet, which soon became a theatre of dissension and open division; and these divisions, whispered about, weakened the government whilst it lasted, and contributed materially to its fall.

Of this short-lived administration, the principal measures were the pacification of Ireland and the bills for economical and parliamentary reform, which, though short of the public expectation, are still the most important acquisitions of that description obtained since the accession of the house of Hanover. The death of Lord Rockingham dissolved the ministry over which he presided. The treasury was immediately offered to Lord Shelburne, on pretence that, having refused it before, it naturally devolved on him on Lord Rockingham's death. His acceptance of it destroyed the former balance of parties in the cabinet, and overset entirely the balance of power in the government. Accordingly Mr Fox and Lord John Cavendish immediately resigned, and, after some interval, they were followed by Lord Keppel. The Duke of Richmond and General Conway remained in office; the latter from simplicity, the former from dissatisfaction at seeing the Duke of Portland preferred to himself as leader of the Whig party. The other members of the cabinet were friends of Lord Shelburne.

Mr Fox has been severely blamed for his precipitancy on this occasion; and, though his resignation was a measure that could not long have been deferred, the time at which it took place makes it perhaps liable to that imputation. It followed so immediately the appointment of Lord Shelburne to the treasury, as to have the appearance of being the result of disappointed personal ambition, rather than of any difference on public grounds. It reduced his friends who were in office to the alternative of immediately following his example, or of passing for adherents of Lord Shelburne; and, as the whole of his motives could not at that time be explained in public, it gave an opportunity to the Duke of Richmond and others to keep their places without forfeiting their characters. It took place at the close of a session of parliament, and left Lord Shelburne and the court for six months in undisturbed possession of the government. It was a cruel disappointment to the public, which had expected a firm and united administration on the principles of those who had opposed the American war and the system that gave rise to it. But to those who judged rightly, the elevation of Lord Shelburne to the treasury was the utter extinction of these hopes. The Rockingham party had found in Lord Shelburne an active and spirited ally in opposition; but they had never been confidentially united with him; and though ready to co-operate with him in a subordinate office, they were not prepared to act under him as premier. It was not the impatience and dissatisfaction of Mr Fox alone that broke up the administration. As soon as the appointment of Lord Shelburne to the treasury was known in Dublin, the Duke of Portland determined to resign his office of lord-lieutenant of Ireland. Lord John Cavendish could with difficulty be prevailed upon to postpone his resignation for a few days. Mr Burke urged strongly to Mr Fox the impossibility of his remaining long in office as a clerk under Lord Shelburne; and it must be owned that, in the subsequent treatment of his colleagues, that nobleman fully justified the apprehensions then entertained of his future conduct. Elated with the fancied possession of court favour, he from that time forward treated the other ministers as mere ciphers; made additions to his cabinet without consulting or even apprising them of his intentions; and is even said to have settled and concluded the terms of his peace with France, without the advice or participation of his secretaries of state.

There were, besides, before the death of Lord Rockingham, differences of such importance in the cabinet as must have led to a dissolution of the administration. It was the policy of Mr Fox to detach Holland and America from their unnatural connection with France; and the great object of his foreign politics was, to form a continental alliance as a balance against the house of Bourbon. The system of Lord Shelburne was to conciliate France, to cultivate a confidential understanding with her government, and to treat her allies as so many inferior and dependent powers. Mr Fox had recommended and carried in the cabinet (23d May 1782) a resolution to instruct Mr Grenville, his majesty's plenipotentiary at Paris, to propose the independence of America in the first instance, instead of making it a condition of a general treaty; and this offer, to which his majesty's consent had been obtained, was actually communicated by Mr Grenville to Dr Franklin. Lord Shelburne, though obliged to acquiesce in the determination of the cabinet, endeavoured afterwards to represent the offer as only conditional, to be recalled if not accepted as the price of peace; and this explanation having been adopted by a majority of the cabinet after the illness of Lord Rockingham, Mr Fox declared his determination to resign. The discovery of a mysterious negotiation at Paris contributed to strengthen this resolution. It was a great object with Mr Fox, in pursuance of his system of policy, to open a free and unreserved communication with Dr Franklin. Through Mr Grenville he had hoped to accomplish this design, and he had nearly succeeded in his purpose, when he had discovered, to his infinite surprise and indignation, that Lord Shelburne had been carrying on a clandestine intercourse with Franklin through Mr Oswald, and had received from him and made to him important communications, which had not been imparted to his colleagues. This discovery, which was made before Lord Rockingham's death, destroyed all confidence in Lord Shelburne among the friends of that nobleman, though, from the delicate nature of the transaction, it was impossible at the time to make it the subject of public animadversion, or even allusion.

The resignation of Mr Fox and his friends compelled Lord Shelburne to strengthen his government from every quarter where support could be obtained. Mr Pitt, who had declined accepting a subordinate office in the Rockingham administration, became his chancellor of the exchequer. Rigby, Dundas, and Jenkinson, old supporters of the American war, attached themselves to his train. A negotiation was opened with the remaining partisans of Lord North, which only failed of success in consequence of Mr Pitt, with more judgment than feeling, making personal objections to Lord North himself, which wounded the pride, and excited the indignation, of his friends and family. When parliament met after the signing of the preliminaries of peace, there were three parties, nearly of equal strength, in the House of Commons; that of the minister, reinforced by the court, and several of the most objectionable members of Lord North's administration; the Rockingham party, who had gone into opposition with Mr Fox; and, lastly, Lord North and his friends. That three separate parties, so equally balanced, should continue to act in the House of Commons without some coalition, was not to be expected. A re-union of the

Whigs would have been most acceptable to the public; but recent differences, mutual recriminations, and distrust of Lord Shelburne, rendered such a coalition impracticable. The personal objections, so harshly and acrimoniously stated, against Lord North, had exasperated his friends against the ministry. Nothing, therefore, remained but a junction of the two parties in opposition; and this coalition, which time would naturally and imperceptibly have brought about, was hastened and matured by the coincidence of their opinions against the peace. The first step was to concert an amendment to the address of thanks on the preliminary articles signed at Versailles; and this amendment was carried in the Commons by a small majority, but not without great indignation being expressed in the house, and a violent outcry raised out of doors, at the apparent junction of the two parties. No coalition had yet taken place. Lord North was still at liberty to have formed an administration without Mr Fox; and it was the opinion of one of the most judicious friends of the latter, that to undertake the government with Lord North, "was to risk their credit with the public on very unsafe grounds." On the part of the Whigs there seems to have been a momentary hesitation whether to proceed farther or to step back. "Unless a real good government is the consequence of this junction," says one of the most sagacious of the party, "nothing can justify it to the public." "There never was a case of more difficulties and dangers to the real friends of whiggism and good principles." The die was at length cast; and in an evil hour, if we are to judge, not from principles, but from results, the coalition was effected. The united strength of the two parties procured a vote of censure on the peace. Lord Shelburne, who still flattered himself with the possession of court favour, is said to have proposed an immediate dissolution of the parliament. But he had served his turn, and was no longer wanted. His majesty judged rightly, that the time was not yet come for so bold a measure, and allowed his minister to resign.

A long interval ensued before the coalition administration was formed. Repeated attempts were made to detach Lord North from Mr Fox; and when these had failed, it was stated as an indispensable preliminary to any ministerial arrangement, that Lord Thurlow should be continued as lord high chancellor. But the fatal effects of a secret enemy in the cabinet had been too severely and too recently felt to concede a point of so much importance. A complete change of administration was insisted upon, and was granted at last, but with the worst possible grace, and with every symptom of ill humour and dissatisfaction. It was not merely the triumph of the coalition that filled the royal bosom with such indignation. His majesty considered the Rockingham party as enemies to his just prerogative. Nor could he forgive them for their zeal against the American war, and inflexibility, when they came into office, in insisting on the unconditional acknowledgment of American independence. "The extraordinary and never to be forgotten vote of February 1782, and the hurry for negotiation that after ensued," had, in his opinion, lowered the spirit of the country, and given confidence to its enemies; and in his own mind had produced such indifference on political subjects, that he felt no anxiety for the arrival of the definitive treaty, or concern for the delays that retarded its conclusion. When it was suggested to him that a wish on his part to receive a minister from America would be favourably received in that country, and might tend to preserve peace and restore harmony in future, he is said to have replied with bitterness, that to receive a minister from America, he could never say would be agreeable to him; and that he should ever have a bad opinion of any Englishman who could accept being an accredited agent to that revolted state. With such feelings rankling in his mind, is it to be wondered at that his majesty was hostile to an administration, the majority of which had zealously concurred in the grant of independence to America?

The coalition ministry was hardly settled, when a misunderstanding arose about the establishment of the Prince of Wales; and so skilfully had the affair been managed on the part of the king, that if his royal highness had not submitted entirely to his father's pleasure, the administration must have been overturned almost as soon as formed. But though no change was attempted before the meeting of parliament, his majesty contrived on every occasion to show ill humour to his ministers, and no one in a situation to observe could doubt for a moment that he only waited for a favourable opportunity to turn them out. The India bill afforded such opportunity. That measure was represented as an invasion of chartered rights, as the establishment of a ministerial oligarchy, independent both of prince and people. The nation, disgusted and offended at the coalition, listened with credulity and favour to these accusations. The king, who had carefully disguised his sentiments to the last moment, procured the rejection of the bill in the Lords, through the agency of Lord Temple, and instantly dismissed his ministers.

The coalition ministry was at an end, but its leaders still possessed the confidence of the House of Commons. The cry of secret influence was raised, and more violent addresses carried to the throne than had ever been presented to any prince of the house of Brunswick. Lord Temple, who had accepted the seals, grew frightened at the storm he had raised, and gave in his resignation. Even Mr Pitt became alarmed in the progress of the contest; and the firmness of the Duke of Richmond alone prevented him from following the example of his kinsman. But, as the struggle proceeded, the voice of the people was every day more unequivocally declared in support of the new administration. Courtiers and reformers, churchmen and dissenters, squires and nabobs, joined in execrating the coalition and applauding the minister, in professions of attachment to the king, and declarations of hostility to the Commons. After the attempt of the country gentlemen to make a new coalition of parties had failed, the majorities of opposition began to diminish; and when some necessary votes had been obtained, this refractory House of Commons was punished by a premature dissolution, for its want of subserviency to the crown.

Our limits will not permit us to follow with the same minuteness the political life of Mr Fox in the subsequent parts of his public career. From 1784 to 1792 he was leader of a powerful party in the House of Commons, in opposition to Mr Pitt. His most remarkable exertions during that period were against the Westminster scrutiny, on the regency, against the abatement of impeachments by a dissolution of parliament, on the libel bill, and on the Russian armament. He never published nor corrected any of his speeches, except the one on moving a new writ for the borough of Tavistock; and of those which appeared in the newspapers, and have since been collected, his speech on the scrutiny is the only one so well reported as to give the reader an adequate notion of his style of speaking. It failed at the moment in procuring justice for the Westminster electors; but the impression it made on the house was such, that in the following year an end was put to that odious and vexatious piece of chicanery, worthy of the pettyfogging genius of its inventor, but disgraceful to the minister who gave it his countenance and support. We have not room to discuss at length the regency question. The case was new and unprovided for.

There was no direct precedent, nor legal authority in the kingdom to make one. Constitutional analogy pointed out the heir-apparent as the fittest person to exercise the royal authority during the indisposition of the king; and the same analogy indicated the great council of the realm as the body most competent to declare the incapacity and apply the proper remedy. Strict or legal right there was none on either side. The prince had no legal right to the regency; nor till they chose to declare it themselves, had the two houses of parliament any legal right to elect a regent, or to fetter him, previous to his election, with restrictions. The contrivance to create, first a phantom, and then a regent, was a clumsy piece of machinery, nearly allied to treason. The claim of right advanced for the prince was a flimsy speculation of Lord Loughborough, adopted on his authority, without due examination, by Mr Fox, who returned in haste from Italy, while the discussions on the regency were pending. As explained afterwards, the doctrine, if not true, was at least harmless. But the opportunity was skilfully laid hold of by the minister, for the purpose of making his rival unpopular, and of gaining time for the king's recovery, which Addington, who had great experience in such maladies, assured him, from the beginning, would certainly take place. In his argument against the abatement of impeachment by a dissolution of parliament, Mr Fox had the support of Mr Pitt, and never was a more triumphant reply than his answer to the arguments on the other side. Of the libel bill it is unnecessary to say a word. The country still profits by it, and regards it as a most important security to our constitutional freedom. By his exertions on the Russian armament, he had the satisfaction to save his country from at least one unnecessary, unjust, and expensive war. We must hasten to an occasion where his efforts were less successful.

The beginning of the French revolution gave universal satisfaction to the friends of liberty in this country. Soon after the taking of the Bastille, Mr Fox describes it "as the greatest, and much the best event that ever happened in the world;" and adds, "all my prepossessions against French connections for this country will be at an end, and indeed most part of my European system of politics will be altered, if this revolution has the consequence that I expect." When the king of France was brought back from Varennes, a report having been circulated in England that it was the intention of the national assembly to bring the queen to trial for her life, he composed a letter to Barnave, one of the leading members of the assembly, with whom he was personally unacquainted, exhorting him against such a measure of useless cruelty, which could not fail to bring disgrace on the cause of liberty. The letter was never sent, in consequence of the report proving to be unfounded; but we subjoin some extracts from it, in order to show the spirit in which it was written. After an apology for obtruding his advice on one who was unknown to him, except by reputation, and stating the bad impression that any unnecessary severity to the queen would produce in England; after praising the assembly for the firmness they had displayed on receiving the news of the king's escape, and urging them to show as much clemency and moderation in prosperity, as they had manifested coolness and resolution in danger; after stating the argument for sending the queen out of the country, or, at most, for confining her in a place of security, he proceeds as follows: "De l'autre coté, si on la juge cette malheureuse femme, qu'on la condamne, et qu'elle subisse son sort, je ne sais que trop bien que ce seraient les ennemis de la liberté qui en triompheront. On la peindra cette liberté comme feroce et cruelle, on tachera de la rendre odieuse, et parmi les âmes faibles on ne reussira peut-etre que trop bien. Le despotisme a toujours eu l'addresse de se servir des passions des hommes pour les subjuguer. Il a eu à ses gages la superstition et l'intérêt personnel, et il seroit bien facheux que la pitié, la plus aimable de toutes les faiblesses humaines, se rangeât aussi de son coté. Je ne sais si je me trompe, mais il me parait que vous êtes precisément dans la position où vous pouvez faire une action belle et genereuse sans le moindre danger; c'est-à-dire, que vous êtes dans la prosperité la moins equivoque. Vous avez donné par vos travaux la liberté à votre patrie, et vous trouvez dans elle une recompense aussi touchante que juste. Travaillez actuellement pour le genre humain, et faites aimer la liberté à toutes les nations de la terre, en prouvant qu'elle nourrit dans l'âme non seulement les vertus mâles comme le courage et la justice, mais aussi la douceur, la moderation, et la clemence." Such were the sentiments and conduct of a man, who was afterwards represented to his countrymen as the blind apologist of all the horrors of the revolution, and indifferent spectator of the calamities of the royal family of France.

As the revolution departed from its original character of justice and moderation, its favourers in this country began to fall off. Mr Burke, scandalized at the confiscation of church property, was the first of the Whig party to declare against it. His violent and outrageous quarrel with Mr Fox in the House of Commons is too well known to need to be here related. No event of his life had ever given such unfeigned sorrow to Mr Fox, as this breach with his old friend and political instructor. But he had soon many other losses of the same sort to deplore. The excesses of the revolution, the democratic form it assumed, the fear lest its example should prove contagious in England, filled with alarm the older, richer, and more aristocratic members of the Whig party. Younger and more ardent spirits, looking to the goodness of the cause, disregarded the unfitness of the instrument used to promote it; and, exulting in the progress of political freedom abroad, thought the occasion favourable for extending and enlarging our constitutional rights at home. A schism was gradually formed in the Whig party, which the formation of the Society of the Friends of the People, and the royal proclamation in May 1792, brought to a public explosion. Mr Fox was eagerly courted on both sides; but if he appeared to hesitate, it was only to keep his friends, if possible, together, and prevent a permanent separation, which he foresaw would invest the minister, as it did, with absolute power. But the revolution of the 10th of August, the massacres of September, the success of the French arms under Dumourier, the violence and indiscretion of the friends of reform at home, spread a panic terror over the land; and the minister who had trifled and temporised till it was too late, found himself unwillingly forced into a war, which he had not wisdom to avert or genius to conduct.

We cannot follow Mr Fox in his opposition to this disastrous war, nor in his subsequent efforts for the restoration of peace. On no occasion was the vigour of his intellect, the sagacity of his foresight, the firmness and resolution of his character, more conspicuous than during the struggle he maintained against overwhelming majorities from 1792 to 1797. Till the Duke of Portland, and other alarmists of the Whig party, joined administration in 1794, he always flattered himself with the hope of renewing his connection with his old friends, when their fears should have subsided; and at every harsh or violent act of the government his letters express surprise that the men with whom he had acted so long should support such measures. When finally separated from his old aristocratic connections, and convinced by fatal experience that the House of Commons had sunk into the passive instrument of ministerial power, his opinions became gradually more inclined to parliamentary reform, from utter despair of seeing the revival of those party connections to which he had been accustomed to look for the preservation of public liberty. But if he appealed to the constituent body against their representatives, he only followed the example which the court and his great opponent had given in the memorable dissolution of 1784. Nothing indisposed him so much against the House of Commons as the indifference it manifested on every occasion where liberty was infringed, or injustice committed by the government. "Arguments against the war and our alliances," he observes, in a letter written in 1794, "are favourably heard in the House of Commons, though they do not get us a vote; but sentiments of liberty, and complaints of oppression, are very little attended to, however well founded. In short, liberty is not popular; and of those who are attached to it there are too many who have wild and impracticable schemes of government, to which the miserable state we are in, both with respect to foreign affairs and our constitution, gives more plausibility and credit than they are by their own merit entitled to. The country seems divided (very unequally I admit) between the majority, who are subdued by fears or corrupted by hopes, and the minority, who are waiting sulkily for opportunities for violent remedies. The few who are neither subdued enough to be silent through fear, nor desperate enough to give up regular opposition, in expectation of more violent measures, are weak both in numbers and weight; but, though weak, we are right, and that must be our comfort." But, however changed the sentiments of the country, his own opinions of the value of political liberty were not altered. "I believe," says he, in another letter to the same correspondent, "the love of political liberty is *not* an error; but if it is one, I am sure I shall never be converted from it, and I hope you never will. If it be an illusion, it is one that has brought forth more of the best qualities and exertions of the human mind than all other causes put together; and it serves to give an interest in the affairs of the world, which without it would be insipid." "We live," he observes on another occasion, "in times of violence and of extremes; and all those who are for creating, or even for retaining, checks upon power, are considered as enemies to order. However, one must do one's duty, and one must endeavour to do it without passion." After relating the final junction of his old friends with administration, he adds, "You will easily imagine how much I feel the separation from persons with whom I had been so long in the habit of agreeing; it seemed in some way as if I had the world to begin anew; and, if I could have done it with honour, what I should best have liked would have been to retire from politics altogether; but this could not be done, and therefore there remains nothing but to get together what remains of our party, and begin, like Sisyphus, to roll up the stone again, which, long before it reaches the summit, may probably roll down again."

The last of these extracts shows that, notwithstanding the defection of some of the friends he most loved and esteemed, he was still convinced of the necessity of party connections, in order to maintain the cause of liberty in this country. He argues the question at length with his correspondent, and concludes by saying, "But the decisive argument upon the subject appears to me to be this: Is there any other mode or plan in this country by which a rational man can hope to stem the power and influence of the crown? I am sure that neither experience nor any well reasoned theory has ever shown any other. Is there any other plan which is likely to make so great a number of persons resist the temptations of titles and emoluments; and, if these things are so, ought we to abandon a system from which so much good has been derived, because some men have acted inconsistently; and because, from the circumstances of the moment, we are not likely to act with much effect?" It was with great reluctance, however, and with great violence to his own wishes, that he persevered in this fruitless struggle. "I am quite sick of politics," he says in August 1794, "and attend to them only because I think it a duty to do so, and that it would be unbecoming my character to quit them at such a moment." His desire to retire from public life became stronger in the following year. "I grow every day to think less of public affairs," he says in April 1795; "I wish I could be persuaded that it was right to quit public business, for I should like it to a degree that I cannot express; but I cannot yet think that it is not a duty to persevere. I am so sure that secession is the measure a shabby fellow would take in our circumstances, that I think it can scarcely be right for us; but, as far as wishes, no man ever wished any thing more. I am perfectly happy in the country. I have quite resources enough to employ my mind, and the great resource of literature I am fonder of every day. However, events and circumstances may happen which may make that right, which I am sure would be pleasant, and I think it not unlikely but they may."

The popular spirit manifested against the treason and sedition bills, in winter 1795, revived his public zeal, but was far from giving satisfaction to his mind. "My view of things," he writes in November 1795, "is, I own, very gloomy, and I am convinced that in a very few years this government will become completely absolute, or that confusion will arise of a nature almost as much to be deprecated as despotism itself. Ministers mean to bring on the first of these evils, and I cannot disguise from myself that there are but too many who wish for the second." After his success at the Westminster meeting against the bills, he says, "It is clear we have the popularity, and I suspect we shall have it universally among the lower classes. I need not tell you how I dislike this state of things, but I cannot submit quietly to Mr Hume's *euthanasia*, which is coming on very fast." As he became more persuaded of the existence of a strong spirit of liberty among the lower classes, he became more inclined to the popular doctrines of parliamentary reform. In 1796 he expresses himself in the following manner upon that subject: "Perhaps, instead of saying *now* that the power of the House of Commons ought to be first restored, and its constitution considered afterwards, it would be better to invert the order, and to say parliament should first be reformed, and then restored to its just influence. You will observe that I state this opinion as being mine *now*, in contradistinction to those times when the Whig party was only beaten, but not dispersed, and when I certainly *was* of a different opinion. At present I think we ought to go further towards agreeing with the democratic or popular party than at any former period, for the following reasons: *We*, as a party, I fear can do nothing, and the contest must be between the court and the democrats. These last, without our assistance, will either be too weak to resist the court, and then comes Mr Hume's *euthanasia*, which you and I think the worst of all events; or, if they are strong enough, being wholly unmixed with any aristocratic leven, and full of resentment against us for not joining them, will go probably to greater excesses, and bring on the only state of things which can make a man doubt whether the despotism of monarchy is not the worst of all evils."

The time at length arrived when the state of things to which he alluded in his letter of April 1795 came to pass. His remaining political friends were persuaded that it was useless to persevere longer in their parliamentary exertions, and that it was even "in some degree hurtful, as tending to deceive the country into an opinion that the House of Commons was still a place in which it was worth while to try the effect of argument and reason." When he found that no good was to be done in parliament, that no beneficial impression was to be made on the country, and that the friends for whom he was ready to sacrifice his time and inclinations wished him to retire from public life, with doubt and hesitation in his mind as to the propriety of the measure, he gave his consent to the secession; resolving no longer to attend his duty in the House of Commons, unless particularly called upon to do so by his own constituents.

Having once retired to St Anne's, he found such enjoyment in the calmness and tranquillity of a country life, that it was with the utmost difficulty he could now and then be brought back to the House of Commons. The happiest years of his life were those which he passed in retirement from 1797 to 1802. He still took a lively interest in public concerns, and applauded and encouraged the exertions of his friends when they returned to parliament, but he could seldom be induced to follow their example. His time passed placidly and agreeably in books, conversation, and the society of his family. He had always been fond of gardening, and his residence in the country gave him a turn for farming. Of the amusements of his early years the love of shooting was the only one in which he continued to indulge, and the exercise it gave him preserved his health. His passion for literature, which had never subsided entirely, revived and became stronger than ever. Poetry and criticism were his favourite pursuits, and history his amusement. He applied with ardour to the study of the Greek tragedians, and as his proficiency increased, he found an agreeable occupation for his mind in the niceties and difficulties of that noble language. Some time after his retreat he conceived the plan of writing a History of the Revolution of 1688. He had many years before expressed himself in the following manner, of the work of our great historian: "I think Mr Hume's History of Charles I. the most mischievous book that ever was written. It is written with infinitely more art than any other part of his work, and is, I think, in that view a masterpiece. I do not think any answer to it or comment on it would do much good, or at least not so much as another history of the times written with his art, or even with the half of it, in the opposite view." But, though his opinion of the utility of a new history of the civil war, as an antidote to Hume, may possibly have first turned his thoughts to a work on English history, the period he selected for his own labours shows that he had no intention to set himself up as a rival to that great historian. His sole object seems to have been, to tell the story of the Revolution, to explain how it was brought about, and to show in what its constitutional value consisted. Had he lived to complete his plan, the criticisms on Hume, in his introduction, would have formed but a small part of his book.

Mr Fox went abroad with Mrs Fox in summer 1802, partly from curiosity to see France after the extraordinary changes that had taken place in that country, and partly to collect documents for his history. As the constant friend of peace, he was received with enthusiasm wherever he went by the French people, and treated with distinguished civility and attention by their government. He had several long conversations with the first consul, in which the latter talked to him with the utmost freedom on a variety of topics; on the concordat then recently made, on the trial by jury, on the licentiousness of the English newspapers, on the difference between Asiatic and European society. On one occasion Napoleon having insinuated that Mr Windham was concerned in the assassination plots against his person, Mr Fox vindicated his old friend with warmth against so odious and unfounded an imputation. Having finished his labours at Paris, during which he collected a large mass of materials for his history, he went to La Grange, the country seat of his friend La Fayette, and after passing some days there most agreeably, returned to England.

On his arrival in London he found great irritation in England against the consular government, and an absurd cry for war raised by the newspapers, and re-echoed by all who expected in any way to profit by that calamity. Ministers were apparently undecided, and, in the hopes of confirming them in a pacific disposition, he resolved for a short time to renew his attendance in parliament. "I shall attend on the address," he says, "because, though, if the ministry is warlike, I have no hope of dissuading them; on the other hand, if they are pacific, I may serve in some degree to encourage them." Besides his general objections to war, where it could be avoided with honour, he thought there was "in this case a moral certainty of failing in our object, and of aggrandizing France still more than we had done." Peace should be preserved, "if it could be done with honour;" and he had no doubt it might, provided our government was so disposed. If Pitt, who had not yet declared himself, should be for peace and Addington, there would be no occasion for the old opposition taking an active part; but if he should join the war party, or "hold a conduct between peace and war," then Addington will want support, "and the support given him will be both useful and honourable." He had been told that he should "be as much abused for pacific language now as he had been ten years before, but being in parliament, he was determined not to blink such a question;" and, on making the trial, found "his speech in favour of peace better received by the house than any he had made since the Russian armament." The country in general, he was persuaded, was inclined to peace; and while there was "hope of contributing to prevent war, he felt himself in a manner bound" not to discontinue his attendance in the House of Commons. When the short session before Christmas closed, he still thought ministers sincerely desirous of maintaining peace. "If I have any fears," he says on the 29th of December 1802, "it is only from a suspicion of a want of courage in ministers to speak out what they really think, and if they should *long* continue to be afraid of speaking bold pacific language, ill humours may arise, and war begin without any wish for it in either government."

It has been invidiously said, that Mr Fox, after his return from Paris, was unwillingly dragged from his retirement by the importunity of his friends, in order to support their views in parliament, and that his health and comfort were sacrificed to their party objects. The fact is directly the reverse. It was he who urged them to attend, not they who solicited him. His return to public life was his own spontaneous act, unsolicited and unexpected by his friends. His object, in the first instance, was to assist in the preservation of peace; and when the message in March 1803 had opened his eyes to the real intentions of the ministry, his indignation at the hollowness and duplicity of their conduct made him persevere in his parliamentary attendance. From the state of parties in the House of Commons he began also to entertain hopes of the revival of a Whig opposition, such as had existed before the fatal schism in 1792; and with his opinions of the necessity of party connections, as the only means of maintaining public liberty in this country, there was no personal sacrifice he was not willing to make for the attainment of such an end. The revival of his former connection with his old friends was the object nearest to his heart; and in Lord Grenville, though a new associate, he found, as he had formerly done in Lord North, an honourable coadjutor, with whom he could act in perfect confidence, though they had differed warmly on points that were no longer the subjects of public discussion. He was even ready to form a junction with Mr Pitt, till he discovered that Pitt, though willing to join in opposing particular measures of administration, would not break with the court by going into regular opposition. It is a certain fact, that, of all his party, Mr Fox was the person most anxious to form a coalition with Lord Grenville; and that, whatever difficulties occurred to retard that junction, they arose not from him, but from his friends. He considered then, as he had done from the time of the American war, the influence of the crown to be the most dangerous enemy to good government in this country; and the violence expressed for war, after the royal message, contrasted with what he conceived to have been previously the general disposition for peace, he regarded as a strong confirmation of all his apprehensions. "The king's minister," he says in March 1803, "be he who he may, is in peace, at last, all powerful; whether or not, in case of a war, the universal apprehension of mischief from the weakness of those men could do any thing, may be more of a question, but even in that case I think the crown in earnest would beat us all." This influence, he contended, not only governed men's actions, but even swayed their opinions. "I should not be surprised," he says in January 1804, "if in a short time the present minister is reckoned the ablest man in the kingdom; or, if that cannot be compassed, it will be thought and maintained, that a minister without abilities is the best for this country." He was anxious for a junction of parties, not from motives of personal ambition, but in order to counteract this servility. "A stand should be attempted, which, though unsuccessful at present, will keep something alive against other times. To temporise is certain, absolutely certain, confirmation of the evil; no nation ever did, or ever can, recover from slavery by such methods."

The first distinct overture for a formal coalition of what were then called the new and old opposition, was made in January 1804, and came from the friends of Lord Grenville. It was proposed to co-operate in a systematic opposition, for the purpose of overturning Mr Addington's administration, and of substituting in its place one upon the most comprehensive basis possible. To this proposal Mr Fox was willing to have acceded at once; but, owing to some repugnance on the part of his friends, it was settled that the two parties should co-operate and concert together the measures to be brought forward in parliament, in order to give to their debates and divisions all the strength they could, without any formal or compact engagement in case of success. The same proposition had been made to Mr Pitt, who owned that the present ministry was weak and inadequate to the crisis, that their dismission would be a benefit to the country, and that, in case of such an event, an administration should be formed on the broadest possible basis. If his majesty, on such an occasion, were to send for him, he should think it right to endeavour to comprehend in the arrangement all parties, and even those who had been most hostile to him; but though, on many points, he would support the new opposition if it took place, he was determined never to engage with any set of men in systematic opposition. Such was the state of parties at the meeting of parliament in February 1804. As the session advanced Mr Pitt grew more hostile to ministers; and, after the Easter recess, the three parties in opposition acted in concert with so much vigour, that Mr Addington thought it prudent to resign. Mr Pitt, who was sent for to form a new administration, had previously declared that he would endeavour to form one in conjunction with Lord Grenville and Mr Fox; but if he found his majesty impracticable, he should feel himself bound to try one by himself. The result is well known. His majesty was found to be impracticable on the subject of Mr Fox. Lord Grenville, though unfettered by engagements, refused to concur in an administration from which Mr Fox was excluded; and, by his conduct on this occasion, "satisfied those" persons of the old opposition, "who had been most prejudiced" against a junction of the two parties. Mr Pitt, abandoned by all, except his personal friends and adherents, was compelled to coalesce with the wrecks of the administration he had contributed to destroy.

After various ineffectual attempts, during the recess, to strengthen the government, Mr Pitt found himself obliged, before the meeting of parliament, to take back Mr Addington into office. A fresh quarrel ensued; and, at the close of the session, Mr Addington (now Lord Sidmouth) and his friends again resigned. Insinuations were then thrown out of an intention to negotiate with opposition; but, if such overtures had been made, the new engagements contracted on the Continent, independent of other reasons, must have put a stop to the negotiation. Russia, offended at the arrogance of Napoleon, had expressed her desire to form a closer connection with Great Britain. It had been the advice of Mr Fox that advantage should be taken of this disposition to propose reasonable terms of peace to France, under the mediation of Alexander, and, if these were refused, to conclude a defensive alliance with Russia, but on no account to provoke a fresh Continental war, which must ruin Austria if unsuccessful. Unhappily this advice was not taken. Austria was seduced, or rather bribed, into a declaration of hostilities. The war was pre-eminently unfortunate, and all hope for a time extinguished of any balance to the power of France upon the Continent.

The death of Mr Pitt dissolved the administration he had formed. Lord Grenville was sent for by the king, and had no difficulty in persuading his majesty to accept of the advice and services of Mr Fox. When the different parts of the new administration were to be cast, his hope and desire of peace induced Mr Fox to take the office of secretary of state for foreign affairs; and, before his fatal illness, he had begun a negotiation for peace, with every apparent prospect of success. The short time he was in office prevented him from realizing the sanguine expectations which his friends and the public had conceived from his past conduct and principles of government. It ought to be remembered, however, that it was to his firmness Mr Windham was indebted for the success of his limited service bill; a measure that had to encounter every opposition which power and prejudice could raise against it; and that to his exertions, and to those of Lord Grenville, was owing a resolution of both houses of parliament to abolish the slave trade, which Mr Pitt, in the plenitude of his power, had failed to obtain.

Mr Fox had inherited an uncommonly vigorous constitution; but, about two years before his death, he had an illness at Cheltenham, which probably laid the foundation of the malady that occasioned his death. His attendance on Lord Nelson's funeral, in January 1806, brought on a complaint to which he was ever after occasionally liable. The duties of office, and the fatigue of constant attendance on the House of Commons, did not tend to restore or confirm his health. About the middle of June he had symptoms of dropsy, both general and local, and soon afterwards his complaint had made such alarming progress as to excite the greatest fears for his life. The universal interest excited in his fate afforded the surest evidence of his great popularity. From the remotest corners of the kingdom letters arrived daily to his family, expressing the deepest concern in his situation, and recommending remedies of all sorts for his disease. His malady, in the mean time, gained ground daily, and his physicians were at length compelled to have recourse to the common surgical operation for dropsy of the belly. The relief obtained, as usual, was but temporary. The operation was repeated, and soon after he fell into a state of languor, from which he never recovered He expired on the 13th of September 1806, having retained his senses and understanding to the last. It has been said that his death was accelerated by the exhibition of digitalis, administered in the vain hope of effecting a perfect cure of his disease; but the story is utterly false and unfounded, and has been publicly contradicted by his physicians. The cause of his complaint was ascertained to be a schirrous affection of the liver.

"Mr Fox," to use the words of one who knew him well during the last fifteen years of his life, and who has delineated his character with equal truth, force, and discrimination,[1] "united, in a most remarkable degree, the seemingly repugnant characters of the mildest of men and the most vehement of orators. In private life he was gentle, modest, placable, kind, of simple manners, and so averse from dogmatism, as to be not only unostentatious, but even something inactive in conversation. His superiority was never felt but in the instruction which he imparted, or in the attention which his generous preference usually directed to the more obscure members of the company. The simplicity of his manners was far from excluding that perfect urbanity and amenity which flowed still more from the mildness of his nature than from familiar intercourse with the most polished society of Europe. The pleasantry perhaps of no man of wit had so unlaboured an appearance. It seemed rather to escape from his mind than to be produced by it. He had lived on the most intimate terms with all his contemporaries distinguished by wit, politeness, or philosophy, or learning, or the talents of public life. In the course of thirty years he had known almost every man in Europe whose intercourse could strengthen, or enrich, or polish the mind. His own literature was various and elegant. In classical erudition, which by the custom of England is more peculiarly called learning, he was inferior to few professed scholars. Like all men of genius, he delighted to take refuge in poetry, from the vulgarity and irritation of business. His own verses were easy and pleasant, and might have claimed no low place among those which the French call *vers de société*. The poetical character of his mind was displayed by his extraordinary partiality for the poetry of the two most poetical nations, or at least languages, of the west, those of the Greeks and of the Italians. He disliked political conversation, and never willingly took any part in it."[2]

"To speak of him justly as an orator would require a long essay. Everywhere natural, he carried into public something of that simple and negligent exterior which belonged to him in private. When he began to speak, a common observer might have thought him awkward; and even a consummate judge could only have been struck with the exquisite justness of his ideas, and the transparent simplicity of his manners. But no sooner had he spoken for some time than he was changed into another being. He forgot himself and every thing around him. He thought only of his subject. His genius warmed and kindled as he went on. He darted fire into his audience. Torrents of impetuous and irresistible eloquence swept along their feelings and conviction. He certainly possessed above all moderns that union of reason, simplicity, and vehemence, which formed the prince of orators. He was the most Demosthenean speaker since the days of Demosthenes. 'I knew him,' says Mr Burke, in a pamphlet written after their unhappy difference, 'when he was nineteen; since which time he has risen, by slow degrees, to be the most brilliant and accomplished debater the world ever saw.'

"The quiet dignity of a mind roused only by great objects, the absence of petty bustle, the contempt of show, the abhorrence of intrigue, the plainness and downrightness, and the thorough good nature, which distinguished Mr Fox, seem to render him no unfit representative of the old English character, which, if it ever changed, we should be sanguine indeed to expect to see it succeeded by a better. The simplicity of his character inspired confidence, the ardour of his eloquence roused enthusiasm, and the gentleness of his manners invited friendship. 'I admired,' says Mr Gibbon, after describing a day passed with him at Lausanne, 'the powers of a superior man, as they are blended, in his attractive character, with all the softness and simplicity of a child; no human being was ever more free from any taint of malignity, vanity, or falsehood.'

"The measures which he supported or opposed may divide the opinion of posterity, as they have divided those of the present age. But he will most certainly command the unanimous reverence of future generations, by his pure sentiments towards the commonwealth; by his zeal for the civil and religious rights of all men; by his liberal principles, favourable to mild government, to the unfettered exercise of the human faculties, and the progressive civilization of mankind; by his ardent love for a country of which the well-being and greatness were, indeed, inseparable from his own glory; and by his profound reverence for that free constitution which he was universally admitted to understand better than any other man of his age, both in an exactly legal and in a comprehensively philosophical sense." (Q. Q. Q.)

FRACASTOR, JEROME, one of the most learned men of his time, was born at Verona in the year 1483. Two singular circumstances are related of him in his infancy; one that his lips adhered so closely when he came into the world, that a surgeon was obliged to divide them with his incision knife; and the other, that his mother was killed with lightning, whilst he, though in her arms at the moment, escaped unhurt. Fracastor was a man of such admirable parts, and made so great progress in every thing he undertook, that in time he became eminently skilled not only in the belles lettres, but in most arts and sciences.

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[1] *Character of Mr Fox*, by Sir James Mackintosh. Published in Dr Parr's Collection, entitled *Characters of Mr Fox*, by PHILOPATRIS VARVICENCIS.

[2] This is true of Mr Fox in the latter part of his life only. Till his separation from his old friends in 1793 his mind was too full of political subjects not to take an eager part in political conversation even in private; and, when a young man, instead of being somewhat inactive in conversation, he was very much the reverse. Dr Johnson was mistaken in supposing him habitually silent when in company, and has assigned a reason for his supposed taciturnity quite inconsistent with his real character.

He was a poet, a philosopher, a physician, an astronomer, and a mathematician; and he was also a man of consequence in his time, as appears from the fact of Paul III. having made use of his authority to remove the council of Trent to Bologna, under the pretext of a contagious distemper, which, as Fracastor declared, made it no longer safe to continue at Trent. He was intimately acquainted with Cardinal Bembo, Julius Scaliger, and most of the great men of his time. Fracastor died of apoplexy at Casi, near Verona, on the 8th of August 1553; and in 1559 the town of Verona erected a statue in honour of him. Fracastor was the author of many works, both as a poet and a physician; but never man was more disinterested in both capacities, for as a physician he practised without fees, and as a poet he was indifferent to fame, after which the tuneful tribe in general so ardently aspire. It is owing to this that we have so little of his poetry in comparison of what he wrote; and that, not to mention other compositions, his odes and epigrams, which were read in manuscript with infinite admiration, have now been lost. His medical productions are as follow: 1. *Syphilidis, sive Morbi Gallici libri tres*, Verona, 1530, in 4to, afterwards frequently reprinted; 2. *De Vini Temperatura*, Venice, 1534, in 4to; 3. *Homocentricorum, sive de Stellis liber unus*, and *De Causis Criticorum Dierum libellus*, Venice, 1535, in 4to; 4. *De Sympathia et Antipathia Rerum liber unus; De Contagionibus et contagiosis Morbis, et eorum curatione, libri tres*, Venice, 1546, in 4to. All the poetical productions of Fracastor were collected and printed at Padua, 1728, 8vo. His complete works appeared for the first time under the title of *Hieronymi Frascatorii Veronensis Opera Omnia, in unum proxime post illius mortem collecta; accesserunt Andreæ Naugerii patricii Veneti Orationes duæ, Carminaque nonnulla.* Venetiis apud Juntas, 1555, in 4to. Besides the works already mentioned, there are included in this collection the three following, which appeared for the first time, viz.: 1. *Naugerius, sive de Poetica dialogus; Turrius, sive de Intellectione dialogus, libri* ii.; 2. *Alcon, sive de cura Canum Venaticorum*; 3. *Frascatorius, sive de Anima dialogus.*

FRACHES, in the glass trade, are the flat iron pans into which the glass vessels already formed are put when in the tower over the working furnace, and by means of which they are drawn out through the leers, that they may be taken gradually from the fire, and cool by degrees.

FRACTION, in *Arithmetic* and *Algebra*, a part or division of an unit or integer; or a number which stands to an unit in the relation of a part to its whole. The word literally imports a broken number.

Fractions are usually divided into decimal, sexagesimal, and vulgar. See ALGEBRA and ARITHMETIC.

FRACTURE, in *Surgery*, a rupture of a bone, or a solution of continuity in a bone, when it is crushed or broken by some external cause. See SURGERY.

FRAME, in *Joinery*, a kind of case, in which a thing is set or enclosed, or even supported; as a window frame, a picture frame, and the like.

FRAME, among printers, is the stand which supports the cases.

FRAME, among founders, is a kind of ledge enclosing a board, which, being filled with wetted sand, serves as a mould to cast their works in.

FRAME is more particularly used for a sort of loom, on which artificers stretch their linens, silks, or stuffs, to be embroidered, quilted, or the like.

FRAME, among painters, is a kind of square, consisting of four long slips of wood joined together, whilst the intermediate space is divided by threads into several little squares like a net, and hence sometimes called *reticula.* It serves to reduce figures from great to small, or to augment their size from small to great.

FRAMLINGHAM, a market-town of the county of Suffolk, of the hundred of Loes, eighty-eight miles from London. It is an ancient but well-built town, situated on an elevated spot, near to which is the source of the river Ore. There are ruins of an ancient castle, supposed to have been built by the Saxons, the walls of which are forty-four feet in height, and eight in thickness. This castle was the residence of Queen Mary in 1553. The church is a handsome building, constructed of black flints. The market-place is large, and on Saturday well supplied. The population amounted in 1801 to 1854, in 1811 to 1854, in 1821 to 2327, and in 1831 to 2445.

FRAMMERSBACH, a bailiwick of the circle of the Lower Maine, in the kingdom of Bavaria, extending over seventy square miles. It contains one city, thirty villages, and 764 scattered single houses, with 4650 inhabitants. The city of the same name is situated on the Lahn, and contains 452 houses, and 2460 inhabitants.

FRAMPTON ON SEVERN, a town of Gloucestershire, in the hundred of Whitstone, 108 miles from London. There is here a considerable manufactory of iron and of wire. At high tides the river Severn occasionally floods a large part of the parish. The population amounted in 1801 to 860, in 1811 to 864, in 1821 to 996, and in 1831 to 1055.

FRANCAVILLA, a city of the province of Otranto, in the kingdom of Naples. It is situated in the centre of the province, and surrounded with several small lakes. It contains 11,108 inhabitants, who grow much cotton, and make it into various kinds of goods. It also produces good wine, and has considerable internal trade.

END OF VOLUME NINTH.

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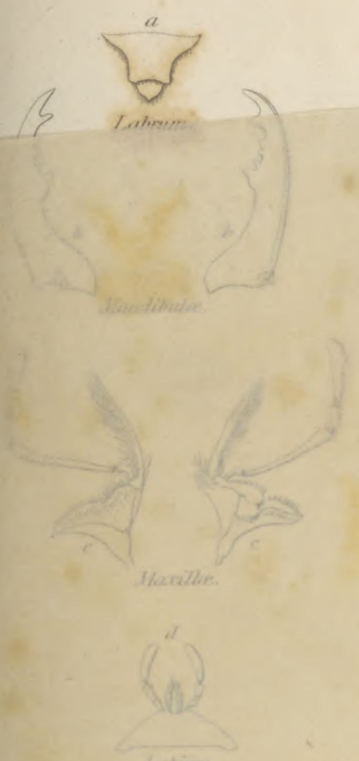
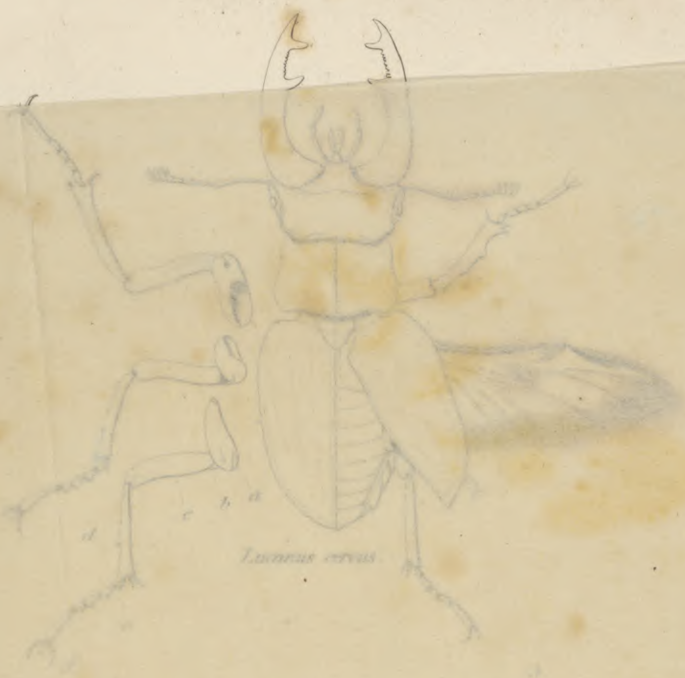


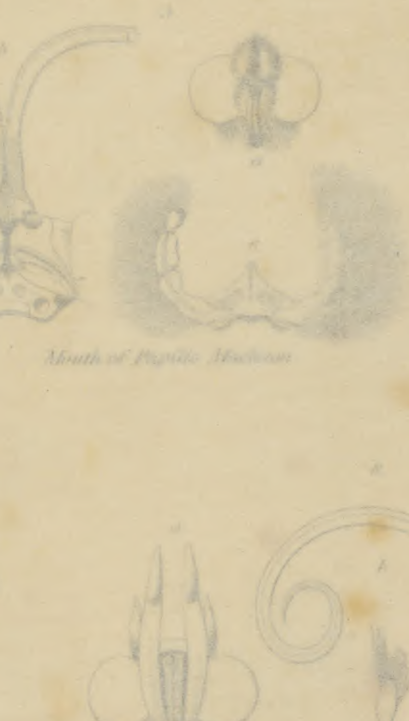
Mouth of Lucanus.

2.

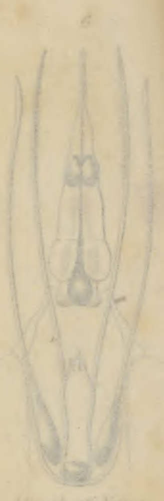


Lucanus cervus.

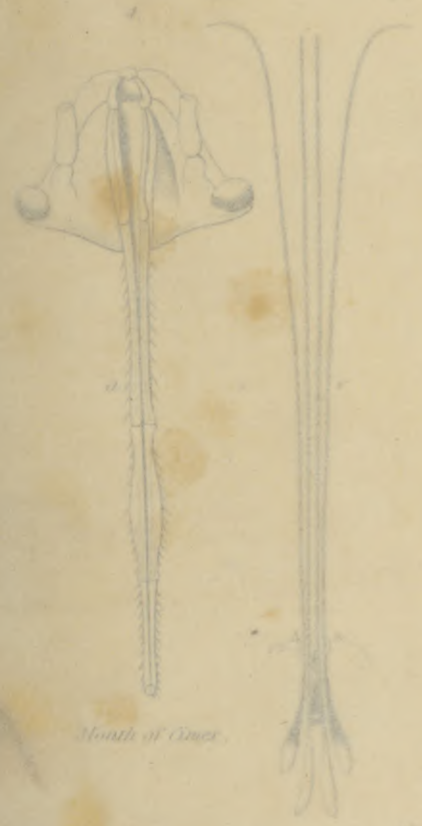
Under side of 2.



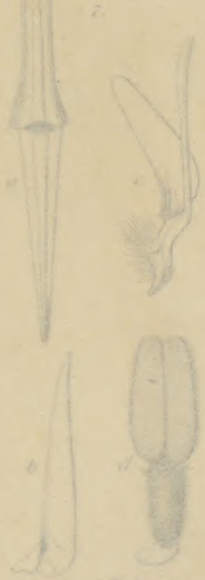
Mouth of Papilio Machaon.



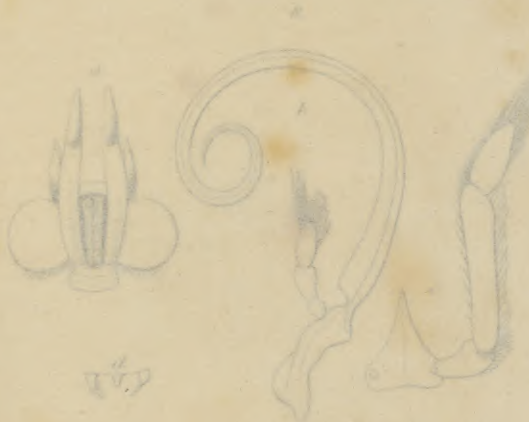
Mouth of Nepa.



Mouth of Cimex.



Mouth of Tabanus.



Mouth of Locusta migratoria.

Net.

Mode of setting.

Forceps.

Mode of setting.

Eng^d by G. Aikman, Edin^r.

He was a poet, a philosopher, a physician, an astronomer, and a mathematician; and he was also a man of consequence in his time, as appears from the fact of Paul III. having made use of his authority to remove the council of Trent to Bologna, under the pretext of a contagious distemper, which, as Fracastor declared, made it no longer safe to continue at Trent. He was intimately acquainted with Cardinal Bembo, Julius Scaliger, and most of the great men of his time. Fracastor died of apoplexy at [illegible], near Verona, on the 8th of August 1553; and in 1559 the town of Verona erected a statue in honour of him. Fracastor was the author of many works, both as a poet and a physician; but never man was more disinterested in both capacities, for as a physician he practised without fees, and as a poet he was indifferent to fame, after which the tuneful tribe [illegible] ardently aspire. It is owing to this that we have so little of his poetry in comparison of what he wrote; and that, not to mention other compositions, his odes and epigrams, which were read in manuscript with extreme admiration, have now been lost. His medical productions are as follow: 1. *Syphilidis, sive Morbi Gallici libri tres*, Verona, 1530, in 4to, afterwards frequently reprinted; 2. *De Vini Temperatura*, Venice, 1534, in 4to; 3. *Homocentricorum, sive de Stellis liber unus*, and *De Causis Criticorum Dierum libellus*, Venice, 1535, in 4to; 4. *De Sympathia et Antipathia Rerum liber unus; De Contagionibus et contagiosis Morbis, et eorum curatione, libri tres*, Venice, 1546, in 4to. All the poetical productions of Fracastor were collected and printed at Padua, 1728, 8vo. His complete works appeared for the first time under the title of *Hieronymi Fracastorii Veronensis Opera Omnia, in unum proxime post illius mortem collecta; accesserunt Andreæ Naugerii patricii Veneti Orationes duæ, Carminaque nonnulla*. Venetiis apud Juntas, 1555, in 4to. Besides the works already mentioned, there are included in this collection the three following, which appeared for the first time: 1. *Naugerius, sive de Poetica dialogus; Turrius, sive de Intellectione dialogus*, libri ii.; 2. *Alcon, sive de cura Canum Venaticorum*; 3. *Fracastorius, sive de Animæ dialogus*.

FRACHES, in the glass trade, are the flat iron pans into which the glass vessels already formed are put when in the tower over the working furnace, and by means of which they are drawn out through the leers, that they may be taken gradually from the fire, and cool by degrees.

FRACTION, in *Arithmetic* and *Algebra*, a part or division of an unit or integer; or a number which stands to an unit in the relation of a part to its whole. The word literally imports a broken number.

Fractions are usually divided into decimal, sexagesimal, and vulgar. See ALGEBRA and ARITHMETIC.

FRACTURE, in *Surgery*, a rupture of a bone, or a solution of continuity in a bone, when it is crushed or broken by some external cause. See SURGERY.

FRAME, in *Joinery*, a kind of case, in which a thing is set or enclosed, or even supported; as a window frame, picture frame, and the like.

FRAME, among printers, is the stand which supports the cases.

FRAME, among founders, is a kind of ledge enclosing a board, which, being filled with wetted sand, serves as a mould to cast their works in.

FRAME is more particularly used for a sort of loom on which artificers stretch their linens, silks, or stuffs, to be embroidered, quilted, or the like.

FRAME, among painters, is a kind of square, consisting of four long slips of wood joined together, whilst the intermediate space is divided by threads into several little squares like a net, and hence sometimes called reticula. It serves to reduce figures from great to small, or to augment their size from small to great.

FRAMLINGHAM, a market-town of the county of Suffolk, of the hundred of Loes, eighty-eight miles from London. It is an ancient but well-built town, standing on an elevated spot, near to which is the source of the river Ore. There are ruins of an ancient castle, supposed to have been built by the Saxons, the walls of which are [illegible] four feet in height, and eight in thickness. This castle was the residence of Queen Mary in 1553. The church is a handsome building, constructed of black flint. The market-place is large, and on Saturday well supplied. The population amounted in 1801 to 1854, in 1811 to [illegible], in 1821 to 2327, and in 1831 to 2445.

FRAMMERSBACH, a bailiwick of the circle of the Lower Maine, in the kingdom of Bavaria, extending over seventy square miles. It contains one city, thirty [illegible], and 764 scattered single houses, with 4550 inhabitants. The city of the same name is situated on the [illegible], and contains 452 houses, and 2460 inhabitants.

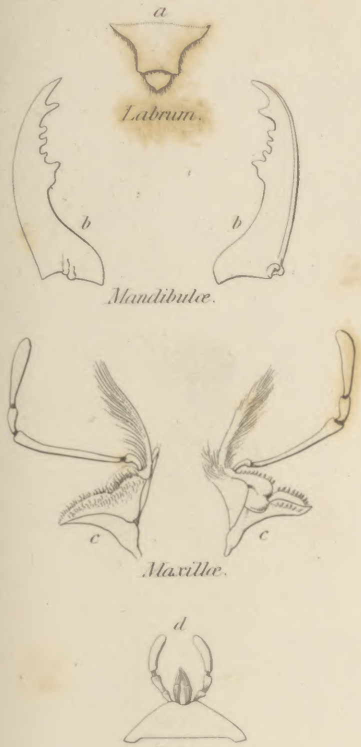
FRAMPTON ON SEVERN, a town of Gloucestershire, in the hundred of Whitstone, 108 miles from London. There is here a considerable manufactory of [illegible] of wire. At high tides the river Severn occasionally [illegible] a large part of the parish. The population amounted in 1801 to 860, in 1811 to 864, in 1821 to 996, and in 1831 to 1055.

FRANCAVILLA, a city of the province of Otranto, in the kingdom of Naples. It is situated in the centre of the province, and surrounded with several small towns. It contains 11,108 inhabitants, who grow much cotton, and make it into various kinds of goods. It also produces good wine, and has considerable internal trade.

END OF VOLUME NINTH.

Printed and Stereotyped by [illegible]

1.



Labrum.

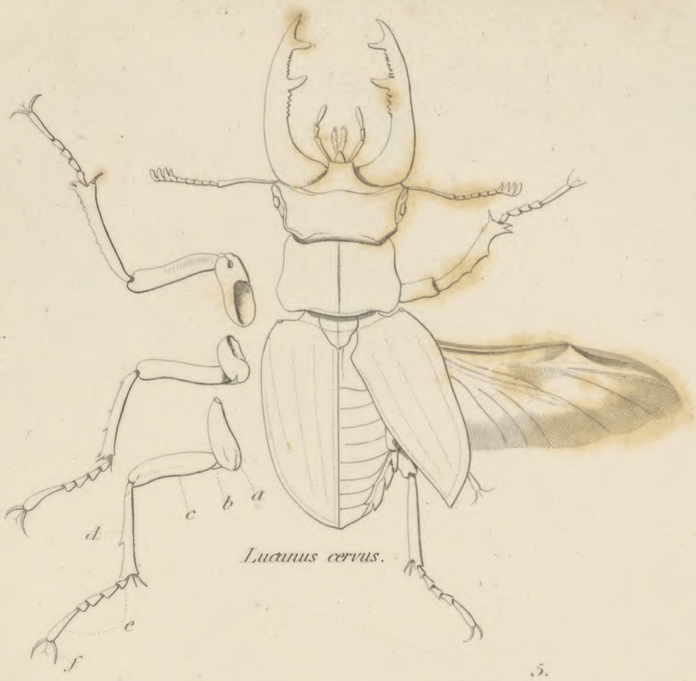
Mandibulæ.

Maxillæ.

Labium.

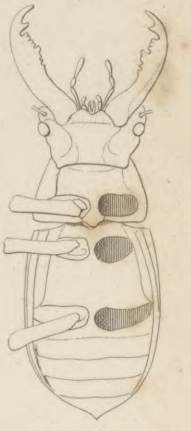
Mouth of Lucanus.

2.



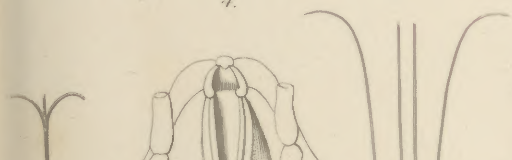
Lucanus cervus.

3.



Under side of 2.

4.



Mouth of Cimex.

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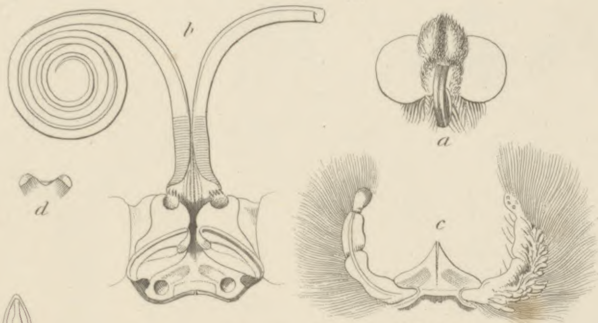

Mouth of Papilio Machaon.

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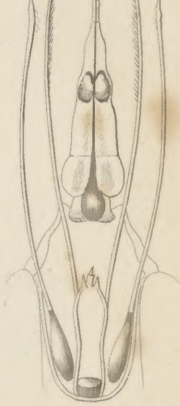
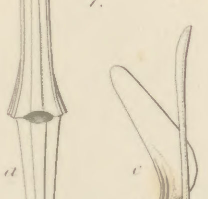


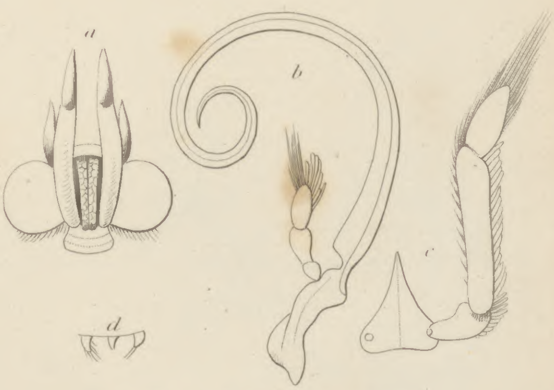
Mouth of Nepa.

7.



Mouth of Tabanus.

8.

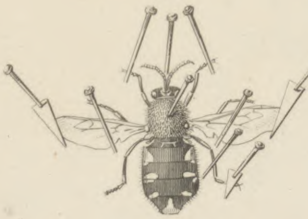


Mouth of Lyndia cannarum.

9.

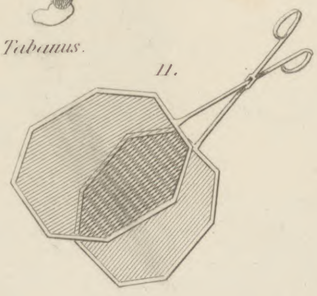
Water Net.

10.



Mode of setting.

11.



Forceps.

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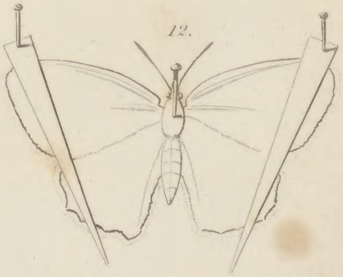
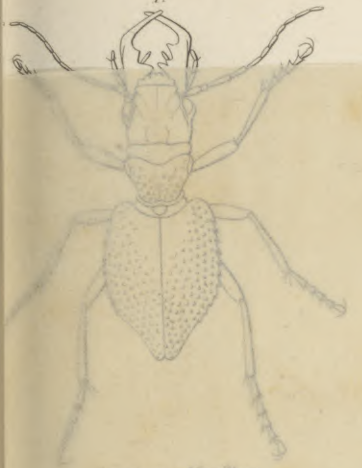


Mode of setting.

Engd by G. Aikman, Edinr

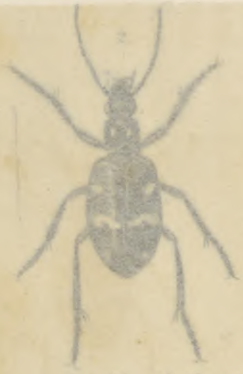
ENTOMOLOGY.

1.



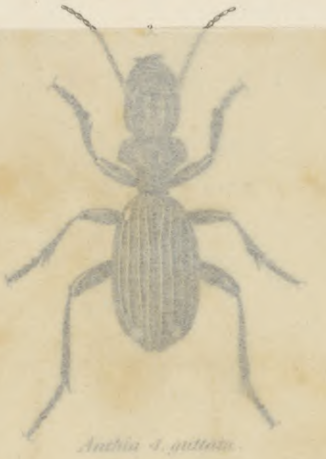
Manticora Maxillosa.

2.



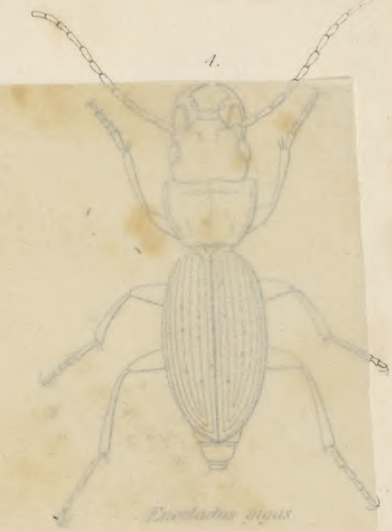
Cicindela sylvatica.

3.



Anthia 4. guttata.

4.



Enceladus gigas.

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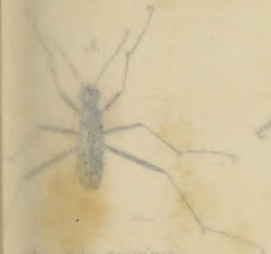
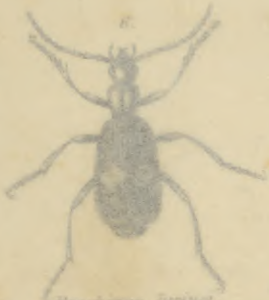


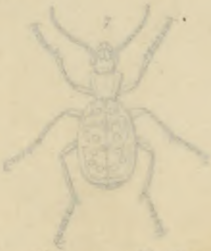
Cicindela tenuipes.

6.



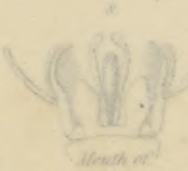
Brachinus Jurinei.

7.



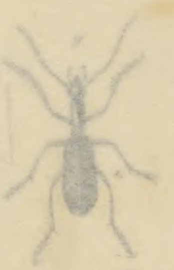
Graphipterus multiguttatus.

8.



Mouth of Anthia 10. guttata.

9.



Dripta ruficollis.

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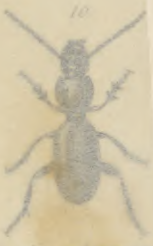

Scarites subterraneus.

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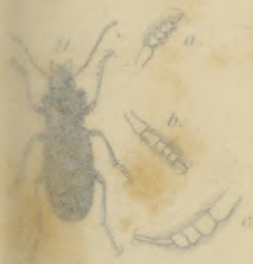
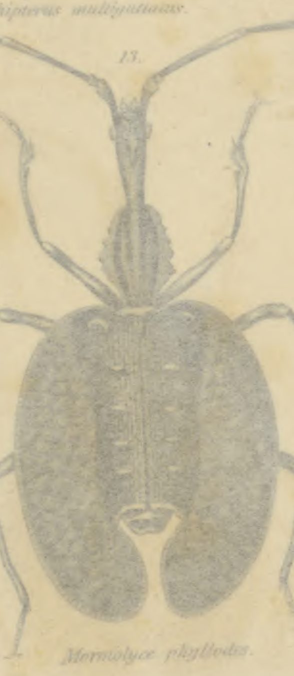


[illegible] tricolor.

13.



Mermolyce phyllodes.

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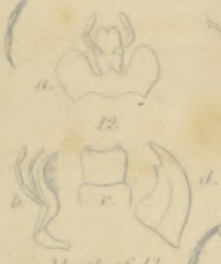

Mouth of 13.

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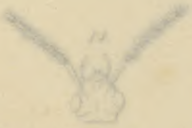
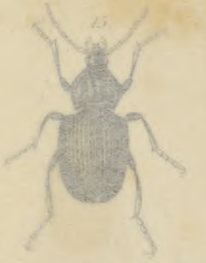


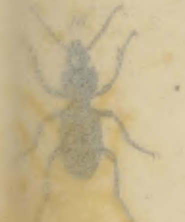
Head of Lor. pilicornis.

15.



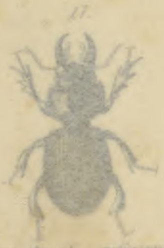
Panagaeus fulgipennis.

16.



[illegible]

17.



Acanthoscelis ruficornis.

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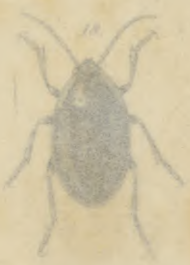

Omophron suturalis.

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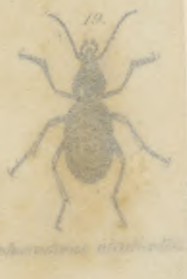

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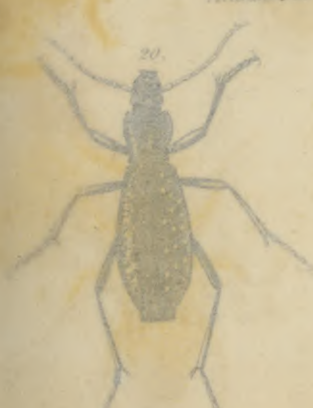

Carabus rutilans.

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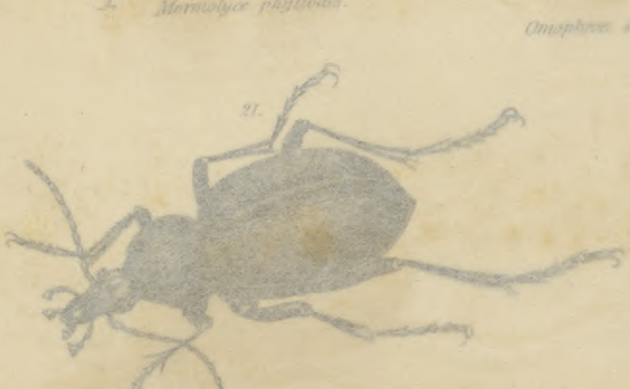

Procerus tauricus.

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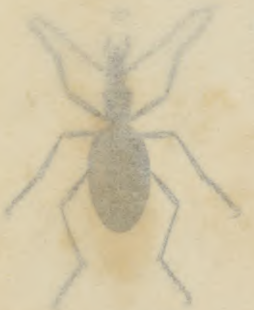
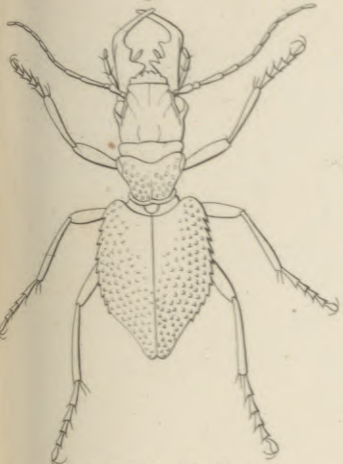


Cychrus italicus.

[illegible]an, Edin^r.

ENTOMOLOGY.

1.



Manticora Maxillosa.

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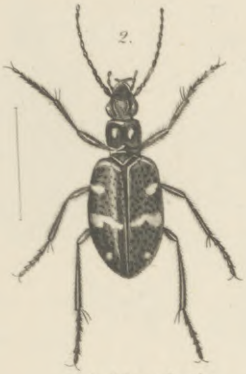
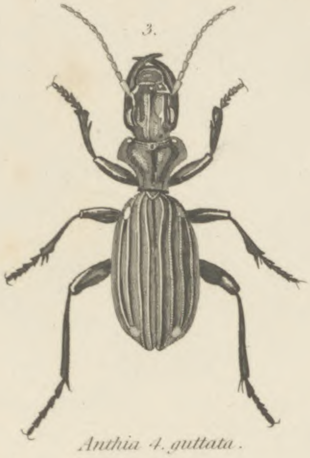


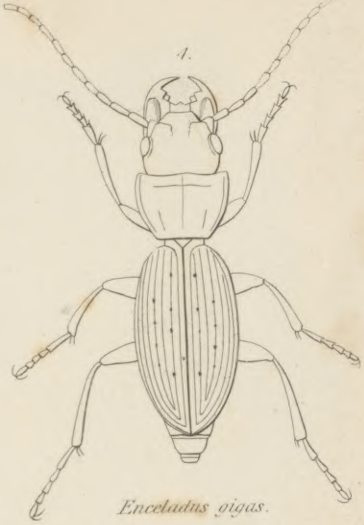
Cicindela sylvatica.

3.



Anthia 4. guttata.

4.



Enceladus gigas.

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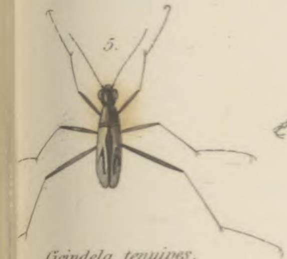

Cicindela tenuipes.

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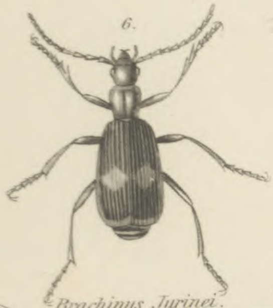
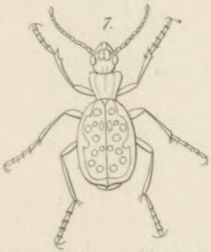


Brachinus Jurinei.

7.



Graphipterus multiguttatus.

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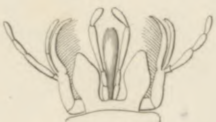
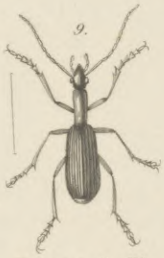


Mouth of
Anthia 10. guttata.

9.



Dripta ruficollis.

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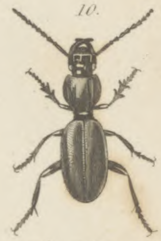

Scarites subterraneus.

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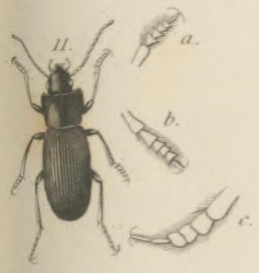

Harpalus tricolor.

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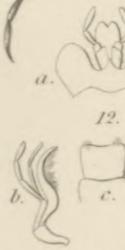
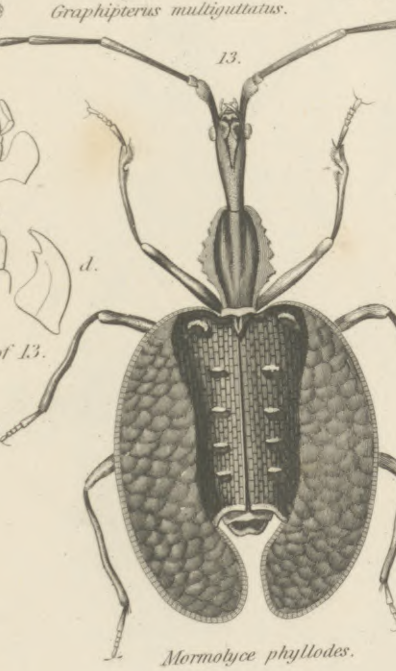


Mouth of 13.

13.



Mormolyce phyllodes.

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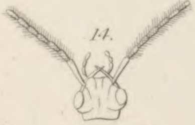
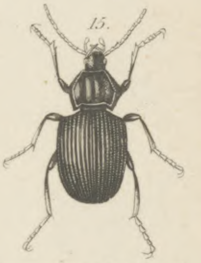


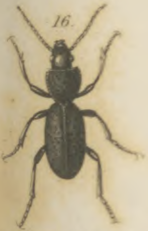
Head of
Lor. pilicornis.

15.



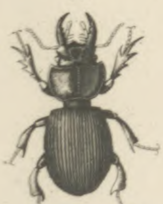
Panagœus fulgipennis.

16.



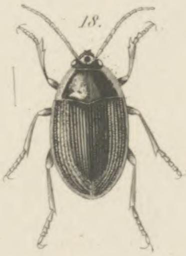
Ditomus violaceus.

17.



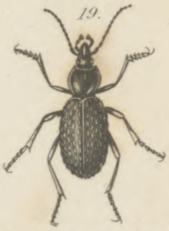
Acanthocelis ruficornis.

18.



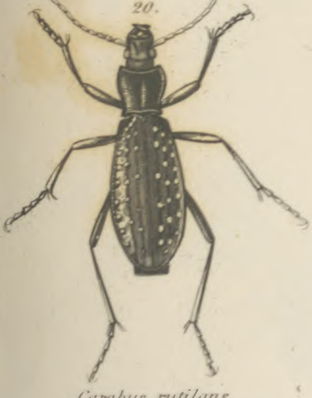
Omophron suturalis.

19.



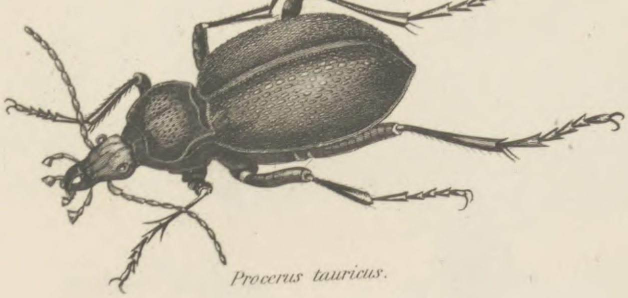
Sphœroderus nitidicollis.

20.



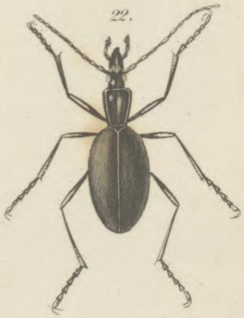
Carabus rutilans.

21.



Procerus tauricus.

22.



Cychrus italicus.

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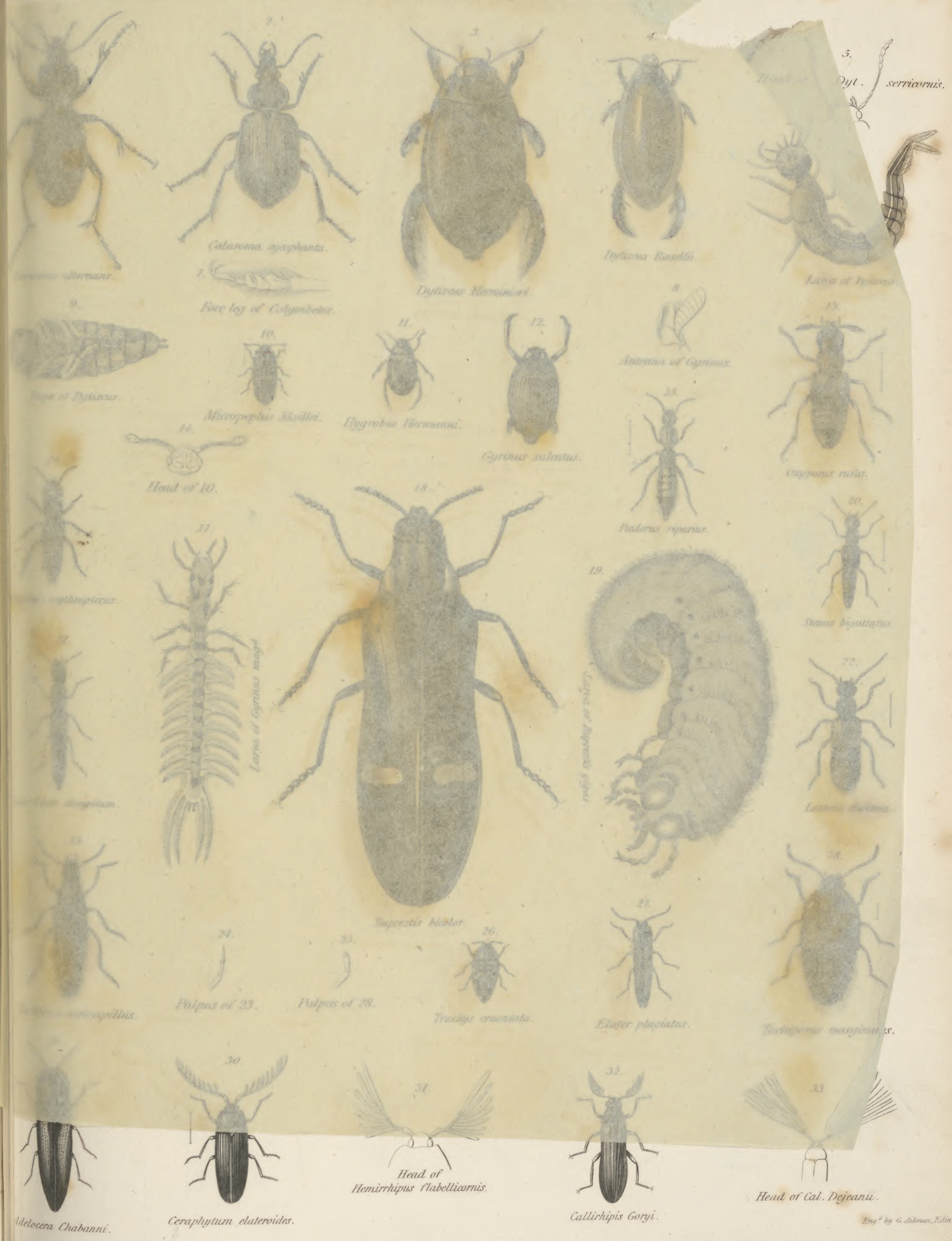

1. [illegible] alternans.

2. Calosoma sycophanta.

3. Dytiscus Herminieri.

4. Dytiscus Roeselii.

5. Head of Dyt. serricornis.

6. Larva of Dytiscus.

7. Fore leg of Colymbetes.

8. Antenna of Gyrinus.

9. Pupa of Dytiscus.

10. Micropeplus Maillei.

11. Hygrobia Hermanni.

12. Gyrinus sulcatus.

13. Oxyporus rufus.

14. Head of 10.

15. Paederus riparius.

16. [illegible] erythropterus.

17. Larva of Gyrinus [illegible]

18. Buprestis bicolor.

19. Larva of Buprestis gigas.

20. Stenus biguttatus.

21. [illegible] elongatum.

22. Lesteva [illegible]

23. [illegible] pellus.

24. Palpus of 23.

25. Palpus of 28.

26. Trachys cruentata.

27. Elater plagiatus.

28. Tachyporus marginatus.

29. Adelocera Chabanni.

30. Ceraphytum elateroides.

31. Head of Hemirrhipus flabellicornis.

32. Callirhipis Goryi.

33. Head of Cal. Dejeanii.

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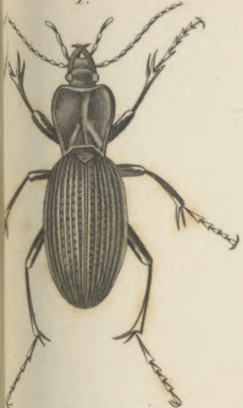
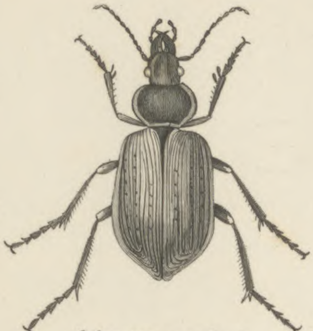
1.



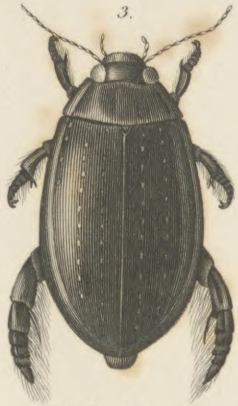
Pamborus alternans.

2.



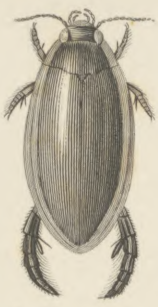
Calasoma sycophanta.

3.



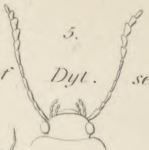
Dytiscus Herminieri.

4.



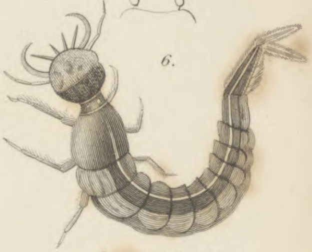
Dytiscus Rœsellii.

5.



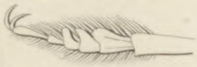
Head of Dyt. serricornis.

6.



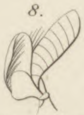
Larva of Dytiscus.

7.



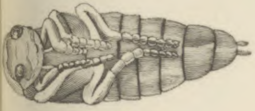
Fore leg of Colymbetes.

8.



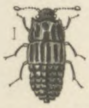
Antenna of Gyrinus.

9.



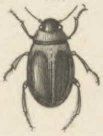
Pupa of Dytiscus.

10.



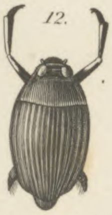
Micropeplus Maillei.

11.



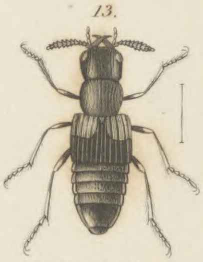
Hygrobia Hermanni.

12.



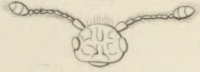
Gyrinus sulcatus.

13.



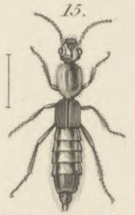
Oxyporus rufus.

14.



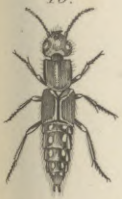
Head of 10.

15.



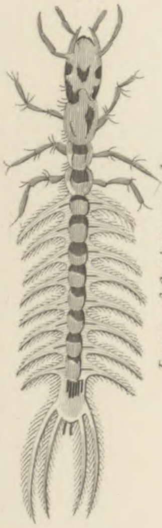
Pœderus riparius.

16.



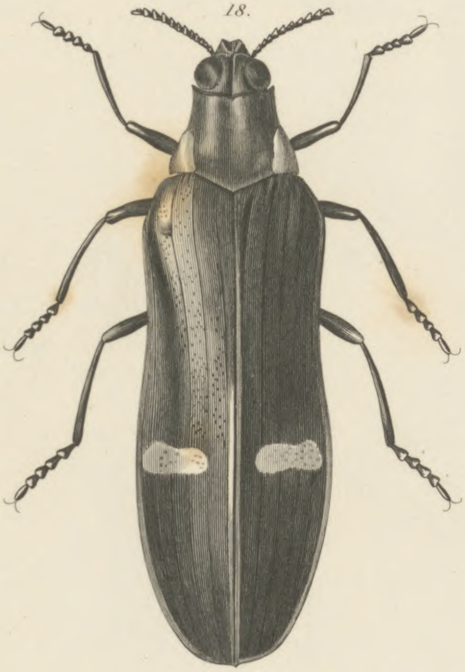
phylinus erythropterus.

17.



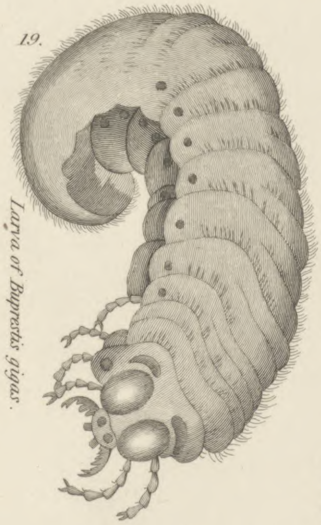
Larva of Gyrinus mag.d

18.



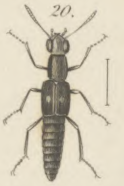
Buprestis bicolor.

19.



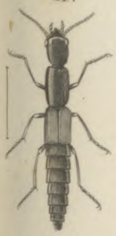
Larva of Buprestis gigas.

20.



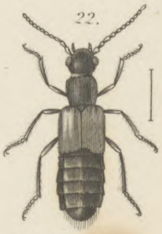
Stenus biguttatus.

21.



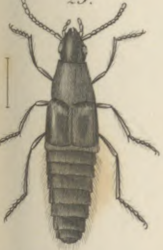
Lathrobium elongatum.

22.



Lesteva dichroa.

23.



Tachinus atricapillus.

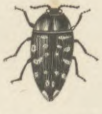
24.

Palpus of 23.

25.

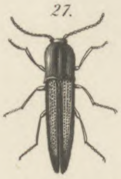
Palpus of 28.

26.



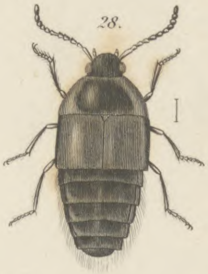
Trachys cruentata.

27.



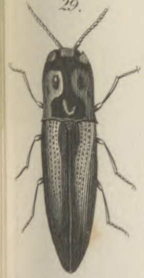
Elater plagiatus.

28.



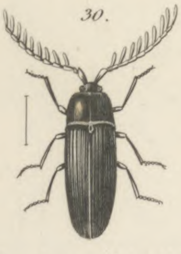
Tachiporus marginatus.

29.



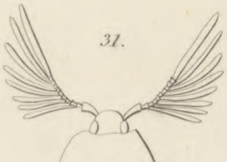
Adelocera Chabanni.

30.



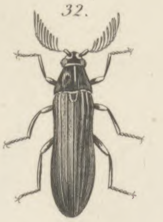
Ceraphytum elateroides.

31.



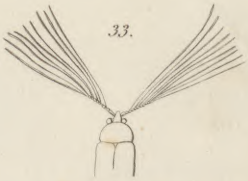
Head of Hemirrhipus flabellicornis.

32.



Callirhipis Goryi.

33.



Head of Cal. Dejeanii.

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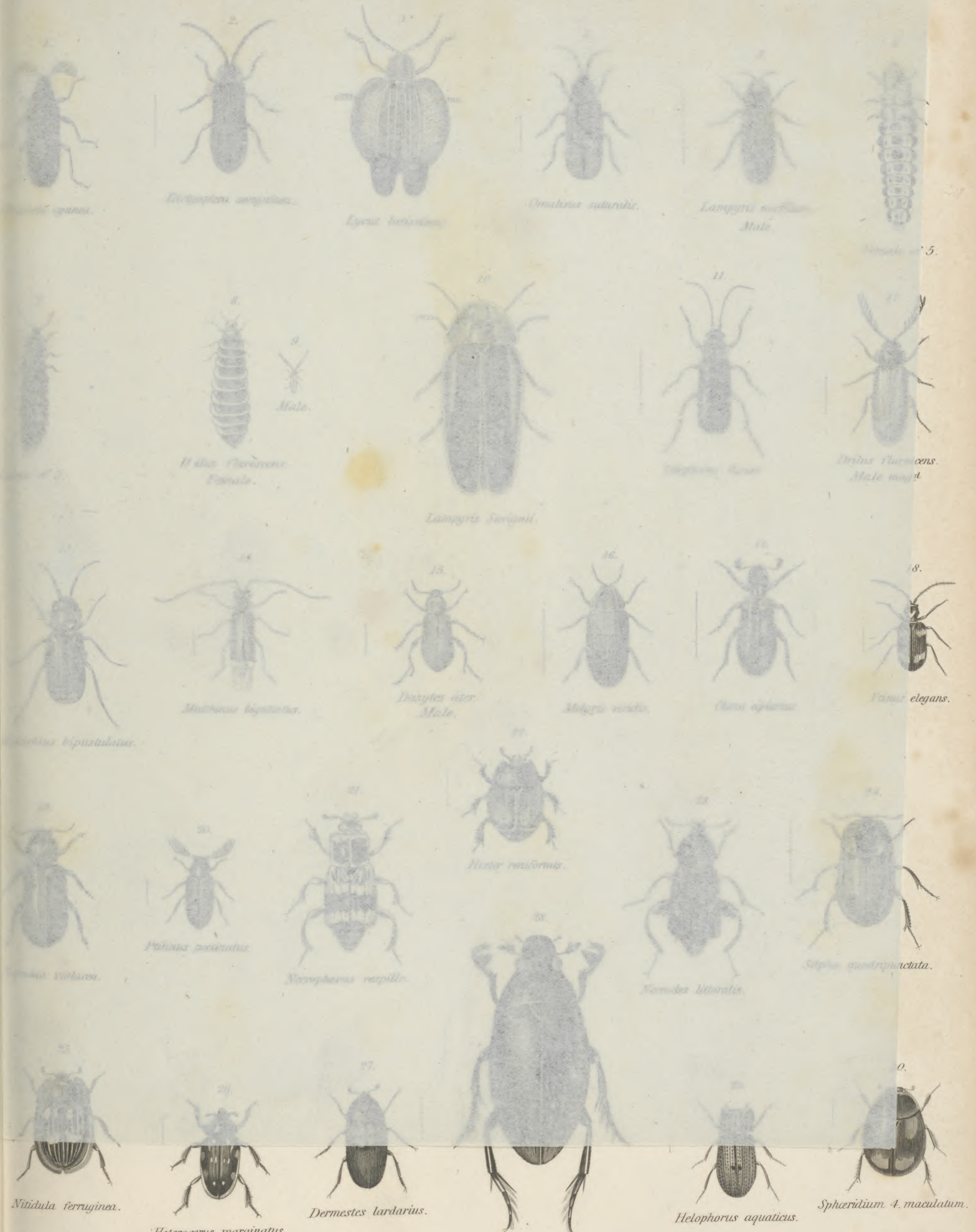
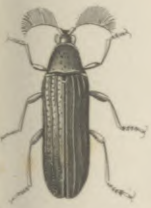
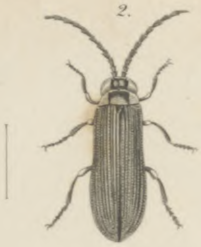
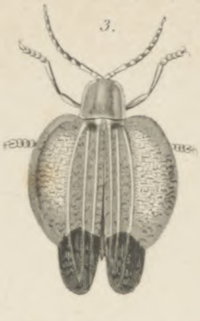
COLEOPTERA. ENTOMOLOGY. PLATE CCXIII.

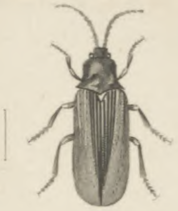


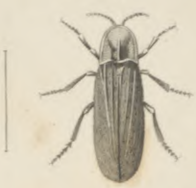
Engd by G. Aikman, Edinr.

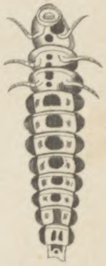
1.

Rhipicera cyanea.

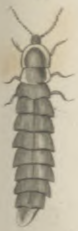
2.

Dictyoptera sanguinea.

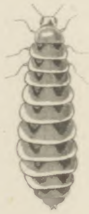
3.

Lycus latissimus.

4.

Omalisus suturalis.

5.

Lampyris noctiluca.
Male.

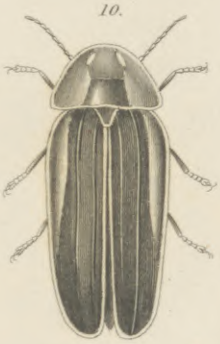
6.

Female of 5.

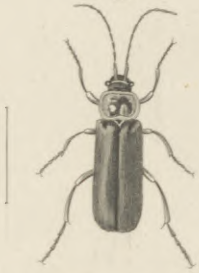
7.

Larva of 5.

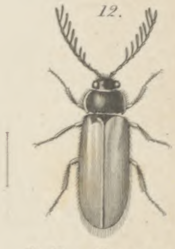
8.

Drilus flavescens.
Female.

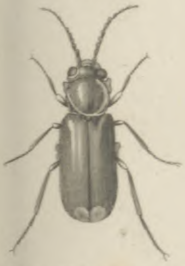
9.

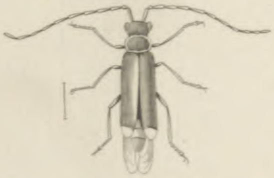
Male.

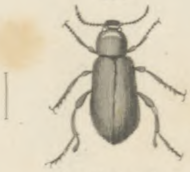
10.

Lampyris Savignii.

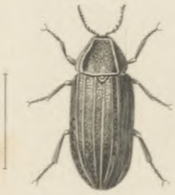
11.

Telephorus fuscus.

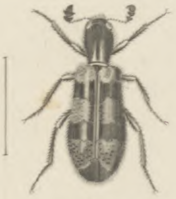
12.

Drilus flavescens.
Male mag^{d}

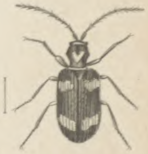
13.

Malachius bipustulatus.

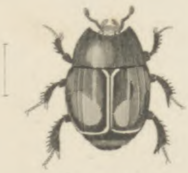
14.

Malthinus biguttatus.

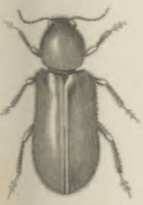
15.

Dasytes ater.
Male.

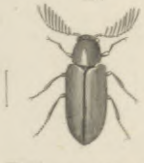
16.

Melyris viridis.

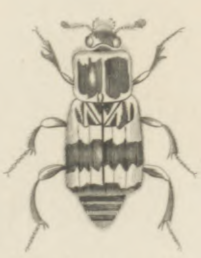
17.

Clerus apiarius.

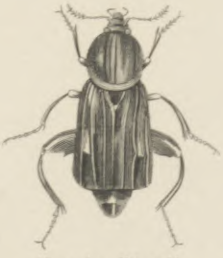
18.

Ptinus elegans.

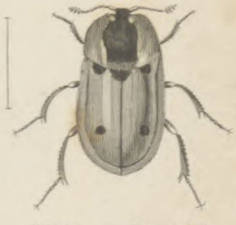
22.

Hister reniformis.

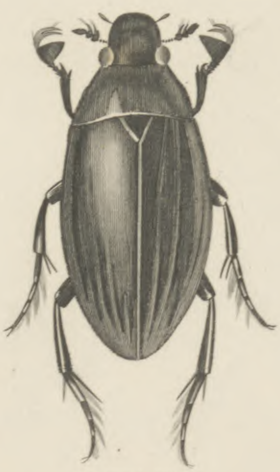
19.

Necrobia violacea.

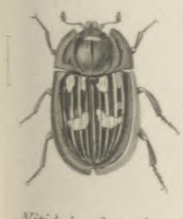
20.

Ptilinus pectinatus.

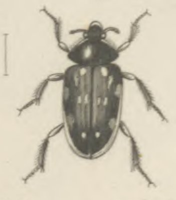
21.

Necrophorus vespillo.

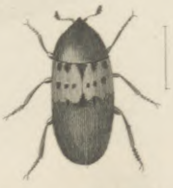
23.

Necrodes littoralis.

24.

Silpha quadripunctata.

28.

Hydrous piceus.

25.

Nitidula ferruginea.

26.

Heterocerus marginatus.

27.

Dermestes lardarius.

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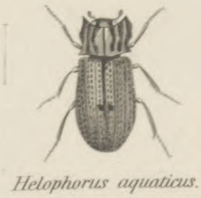
Helophorus aquaticus.

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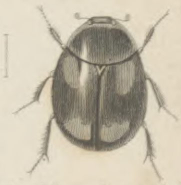
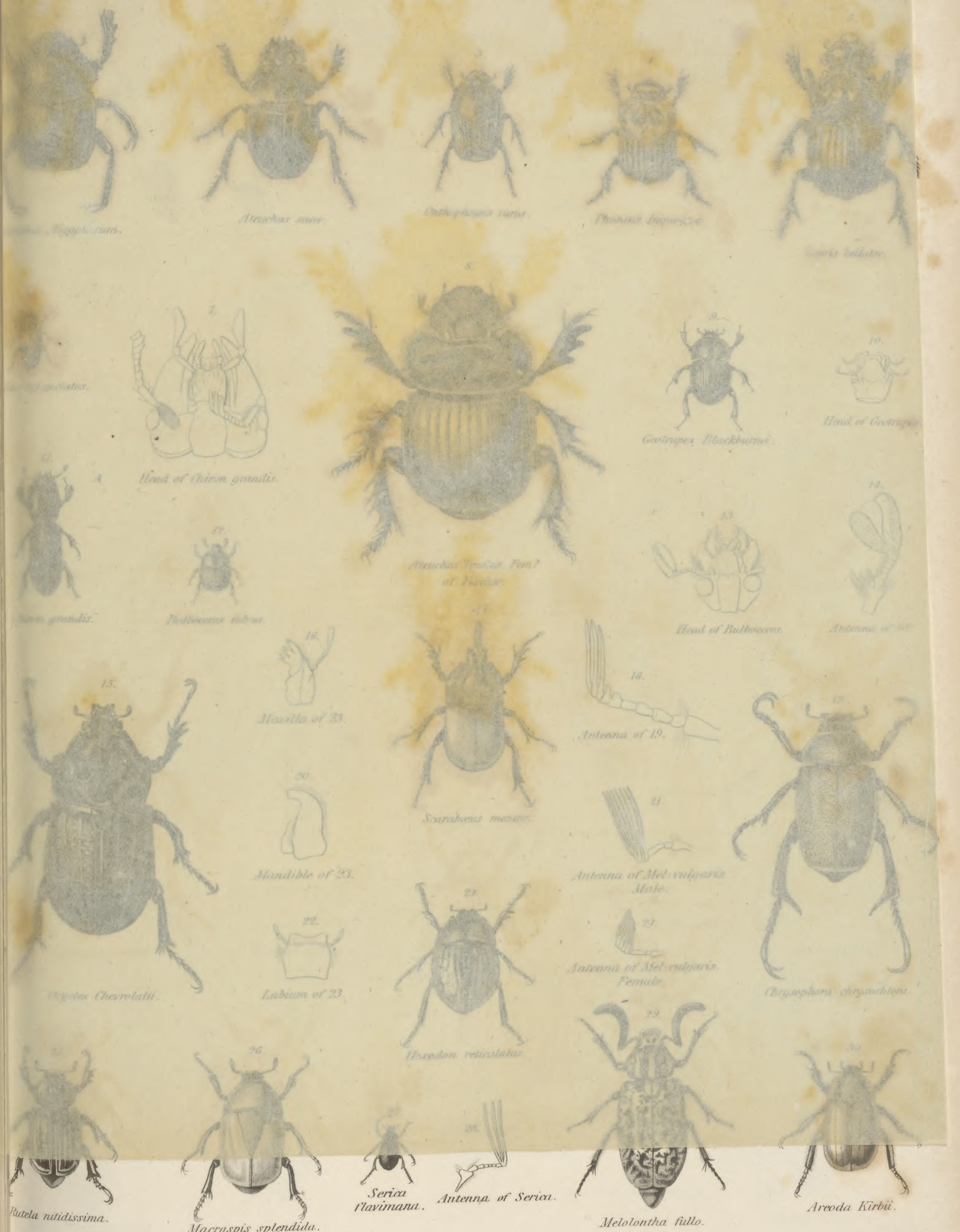

Sphæridium 4. maculatum.

Eng^{d} by G. Aikman, Edin^{r}

ENTOMOLOGY.



Ægyptiacum.

Ateuchus sacer.

Onthophagus taurus.

Phanæus Imperator.

bellator.

atus.

Head of Chiron grandis.

Ateuchus [illegible]. Fem? of Fischer.

Geotrupes Blackburnii.

Head of Geotrupes.

iron grandis.

Bolboceras fulvus.

Head of Bolboceras.

Antenna of

Maxilla of 23.

Scarabæus mentor.

Antenna of 19.

Mandible of 23.

Antenna of Mel: vulgaris Male.

Oryctes Chevrolatii.

Labium of 23.

Hexodon reticulatus.

Antenna of Mel: vulgaris. Female.

Chrysophora chrysochlora.

Rutela nitidissima.

Macraspis splendida.

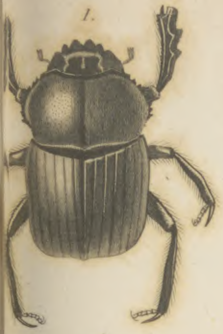
Serica flavimana.

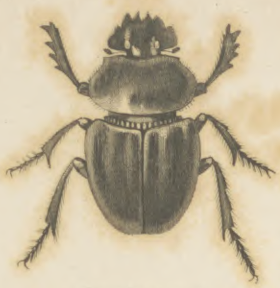
Antenna of Serica.

Melolontha fullo.

Areoda Kirbii.

Engd by G. Aikman, Edin

1.

Ateuchus Ægyptiorum.

2.

Ateuchus sacer.

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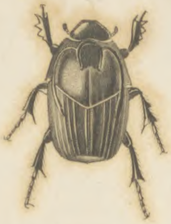
Onthophagus rarus.

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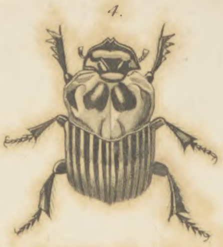
Phaneus Imperator.

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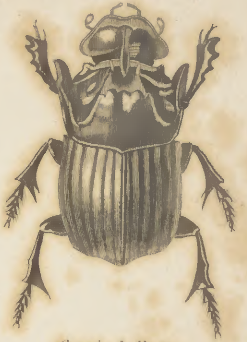
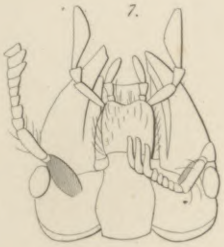
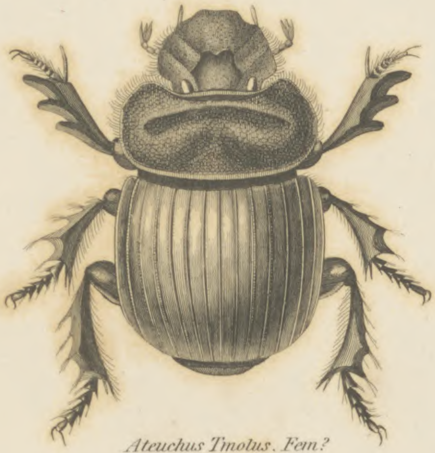

Copris bellator.

6.

dius bipunctatus.

7.

Head of Chiron grandis.

8.

Ateuchus Tmolus. Fem? of Fischer.

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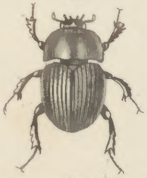
Geotrupes Blackburnei.

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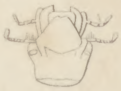
Head of Geotrupes.

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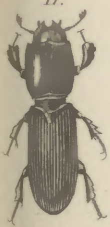
Chiron grandis.

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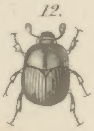
Bulbocerus fulvus.

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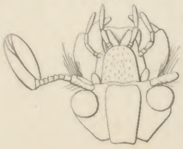
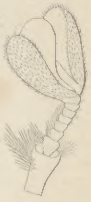
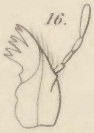

Head of Bulbocerus.

14.

Antenna of Dº

16.

Maxilla of 23.

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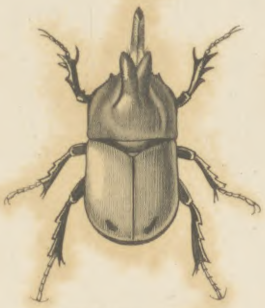
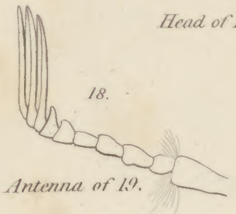
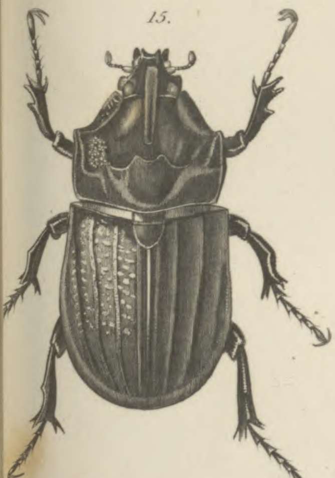
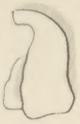
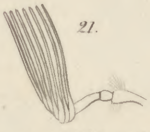
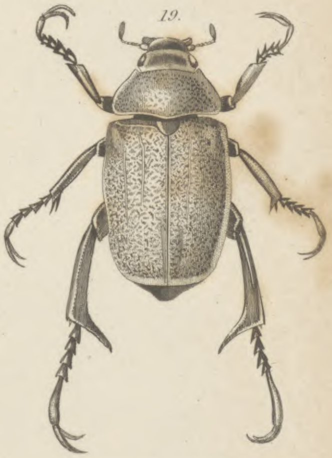

Scarabæus mentor.

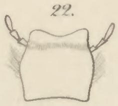
18.

Antenna of 19.

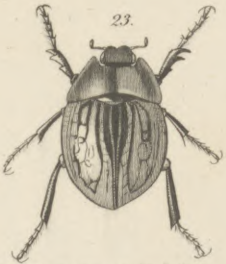
15.

Oryctes Chevrolatii.

20.

Mandible of 23.

21.

Antenna of Mel: vulgaris. Male.

19.

Chrysophora chrysochlora.

22.

Labium of 23.

23.

Hexodon reticulatus.

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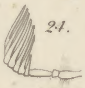
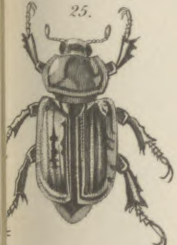

Antenna of Mel: vulgaris. Female.

25.

Rutela nitidissima.

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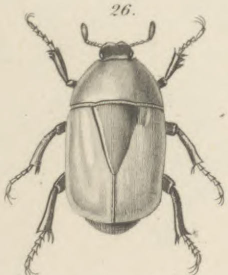
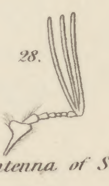
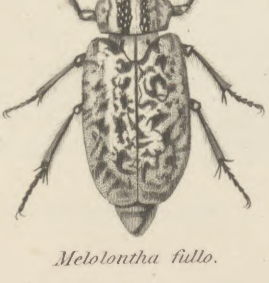
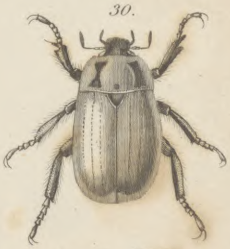

Macraspis splendida.

27.

Serica flavimana.

28.

Antenna of Serica.

29.

Melolontha fullo.

30.

Areoda Kirbii.

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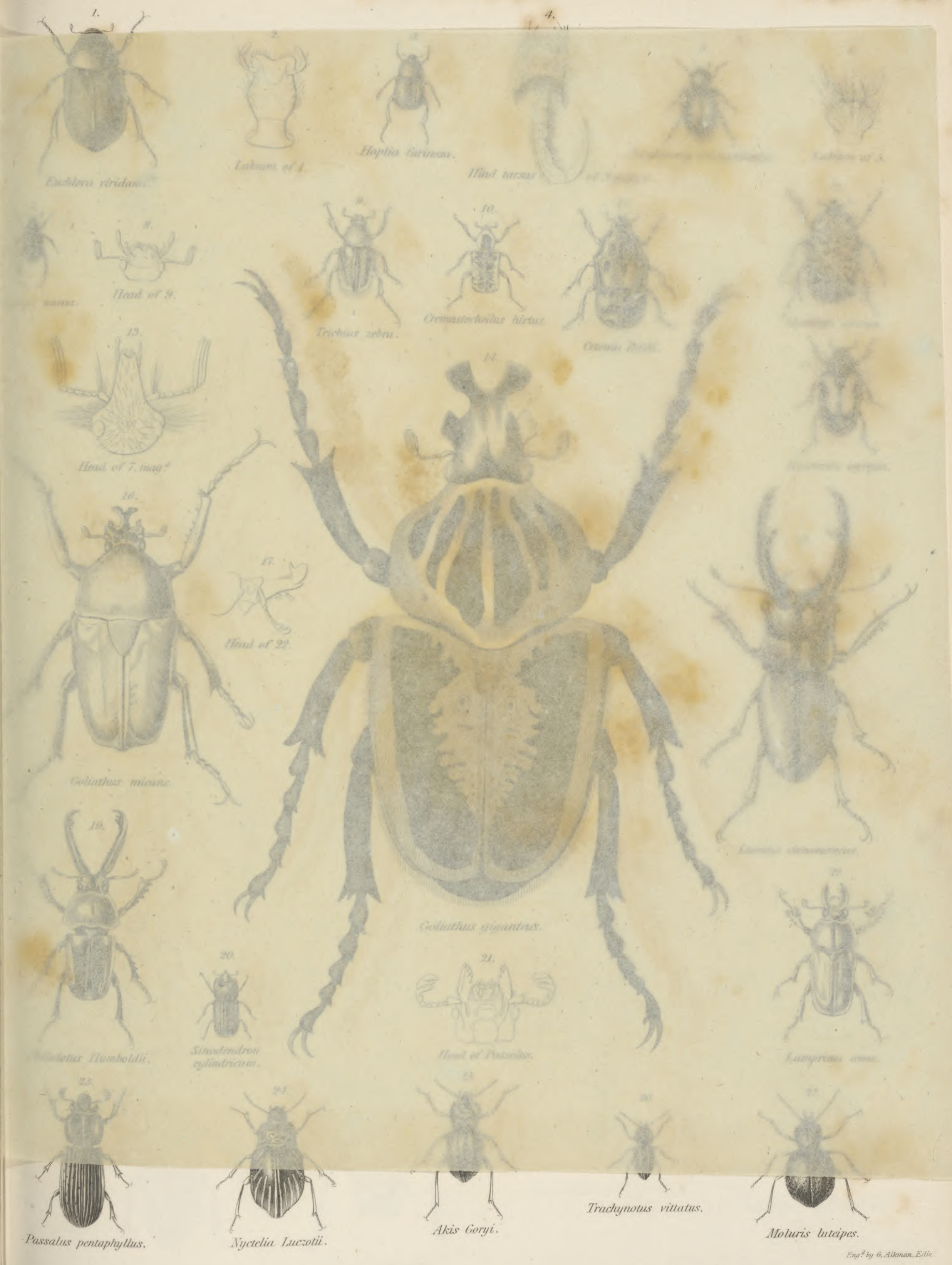
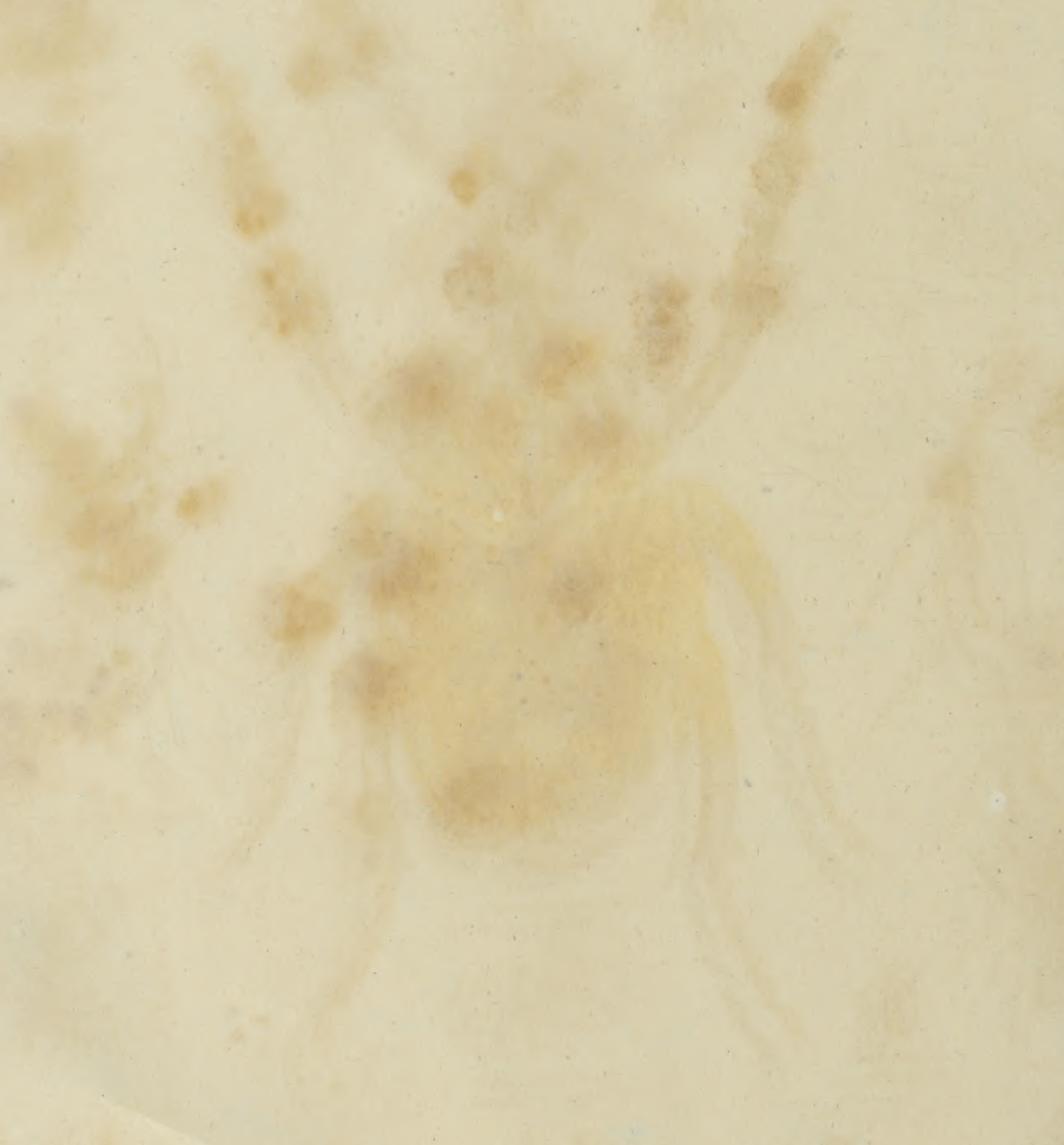
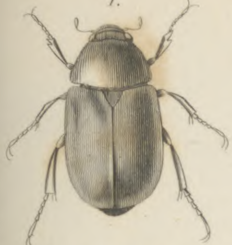

1.
Euchlora viridana.
Labium of 1.
Hoplia farinosa.
4.
Hind tarsus
Labium of 5.
8.
Head of 9.
9.
Trichius zebra.
10.
Cremastocheilus hirtus.
Cetonia
13.
Head of 7. mag.
14.
16.
Goliathus micans.
17.
Head of 22.
Goliathus giganteus.
19.
Humboldii.
20.
Sinodendron cylindricum.
21.
Head of Passalus.
Lamprima
23.
Passalus pentaphyllus.
24.
Nyctelia Luczotii.
25.
Akis Goryi.
26.
Trachynotus vittatus.
27.
Moluris luteipes.
Engd. by G. Aikman, Edin.



ENTOMOLOGY.

1.



Euchlora viridana.

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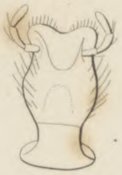
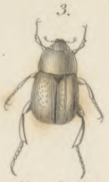


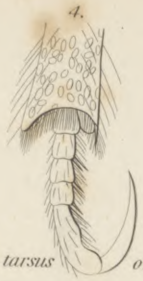
Labium of 1.

3.



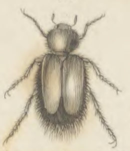
Hoplia farinosa.

4.



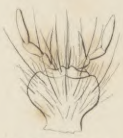
Hind tarsus of 3 mag^{d}.

5.



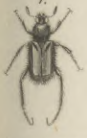
Amphicoma bombyliformis.

6.



Labium of 5.

7.



Anisonyx nasua.

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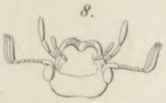
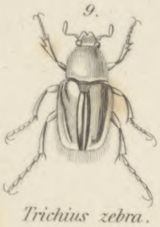


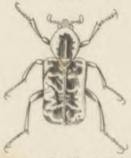
Head of 9.

9.



Trichius zebra.

10.



Cremastocheilus hirtus.

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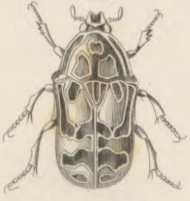
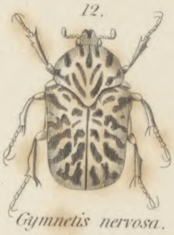


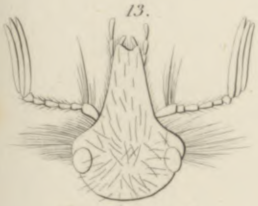
Cetonia Baxii.

12.



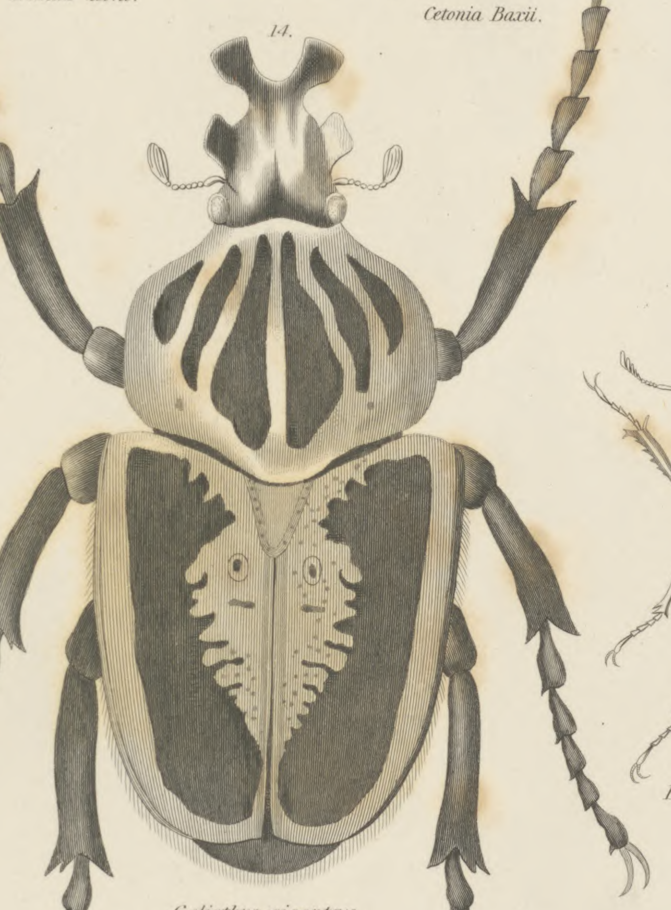
Gymnetis nervosa.

13.



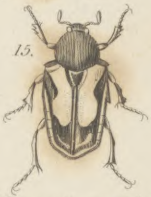
Head of 7. mag^{d}.

14.



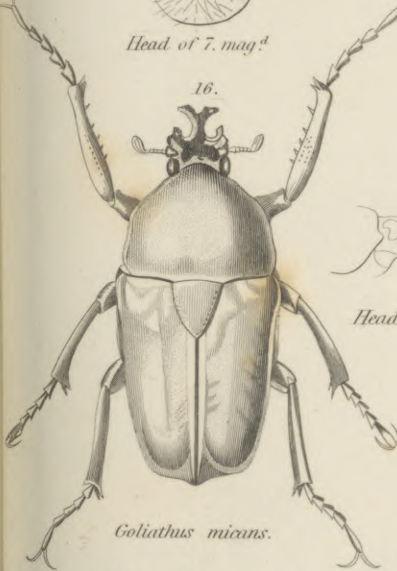
Goliathus giganteus.

15.



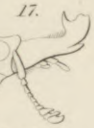
Macronota ægregia.

16.



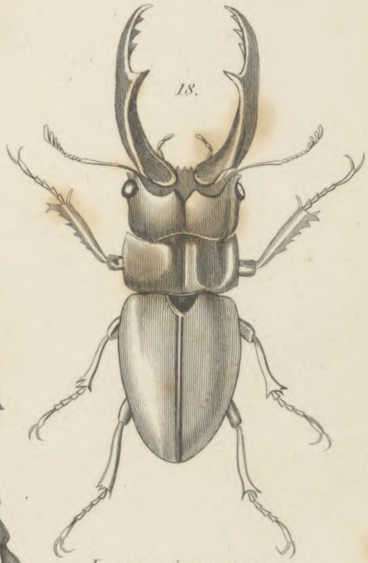
Goliathus micans.

17.



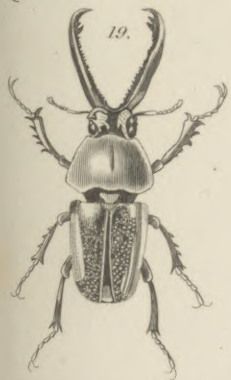
Head of 22.

18.



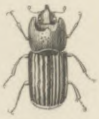
Lucanus cinnamomeus.

19.



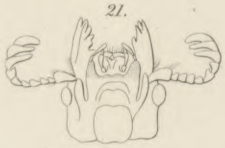
Philodotus Humboldii.

20.



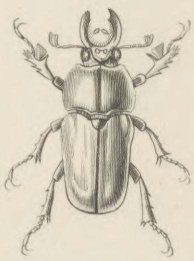
Sinodendron cylindricum.

21.



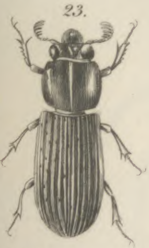
Head of Passalus.

22.



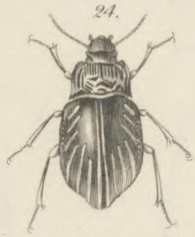
Lamprima ænea.

23.



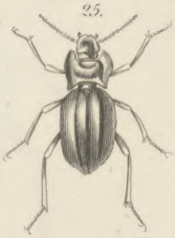
Passalus pentaphyllus.

24.



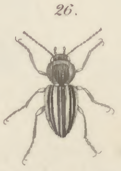
Nyctelia Luczotii.

25.



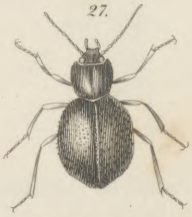
Akis Goryi.

26.



Trachynotus vittatus.

27.



Moluris luteipes.

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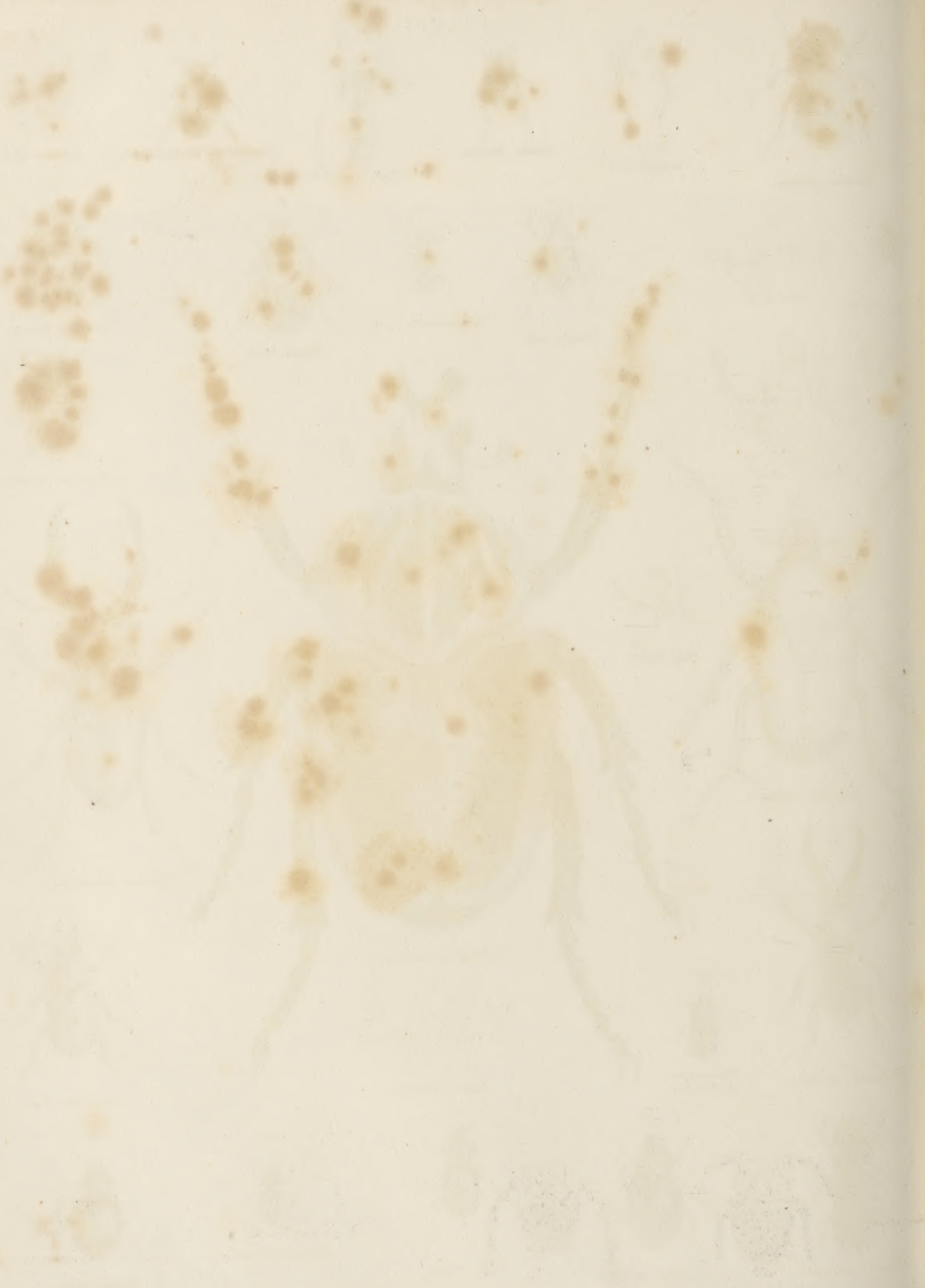
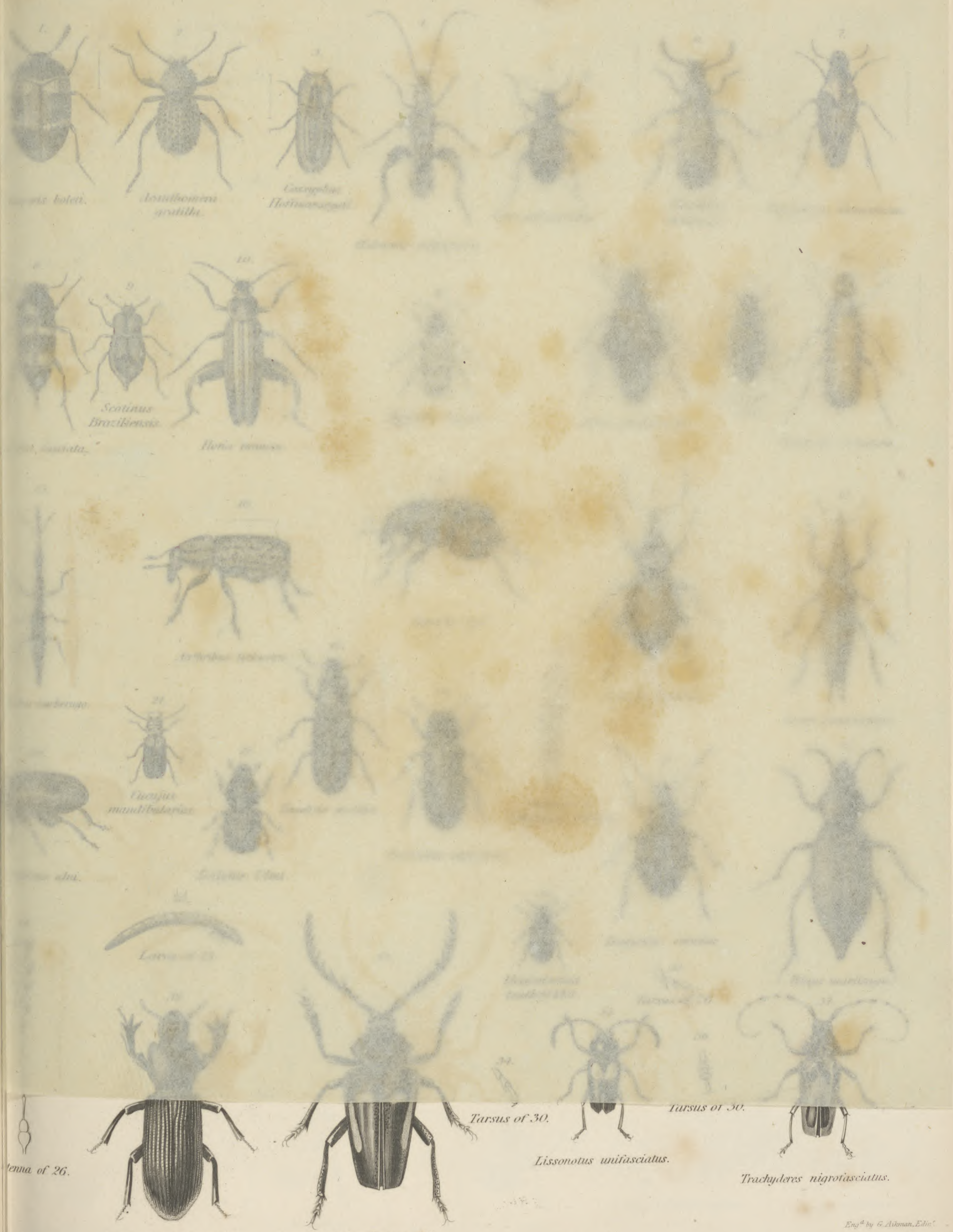




Scotinus Braziliensis.

Cucujus mandibularis.

tenna of 26.

Chiroscelis bifenestrata.

Prionus Desmarestii.

Tarsus of 30.

Lissonotus unifasciatus.

Tarsus of 30.

Trachyderes nigrofasciatus.

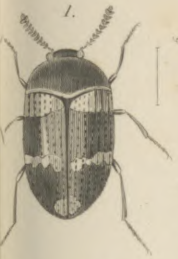
Engd by G. Aikman, Edinr.

LEOPTERA.

ENTOMOLOGY.

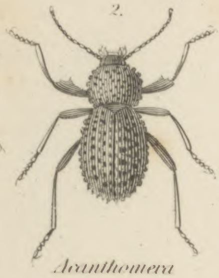
PLATE CCXXVI.

1.



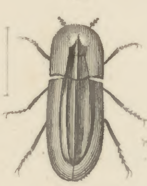
Diaperis boleti.

2.



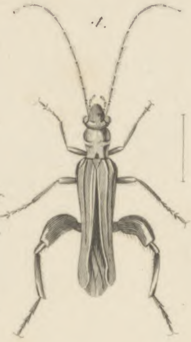
Acanthomera gratilla.

3.



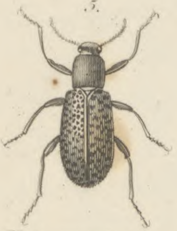
Cossyphus Hoffmanseggii.

4.



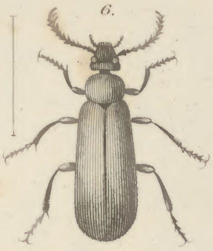
Œdemera podograria.

5.



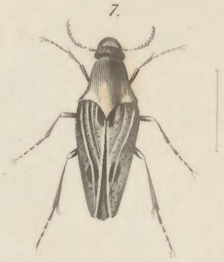
Upis ceramboides.

6.



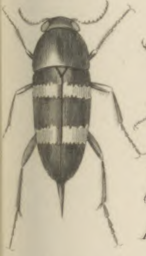
Pyrochroa cardinalis.

7.



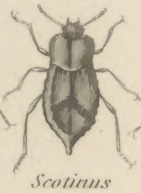
Ripiphorus bimaculatus.

8.



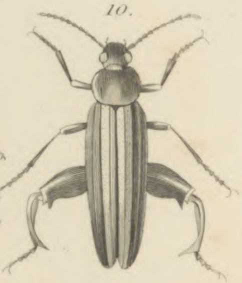
ordella fasciata.

9.



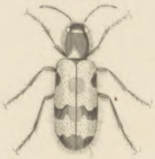
Scotinus Braziliensis.

10.



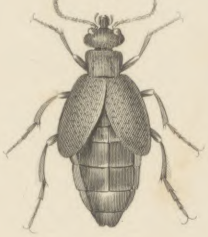
Horia testacea.

11.



Mylabris chicorii.

12.



Meloe proscarabœus.

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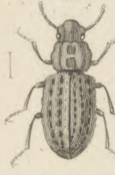

Corticus celtis.

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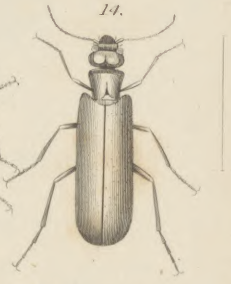
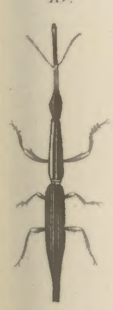


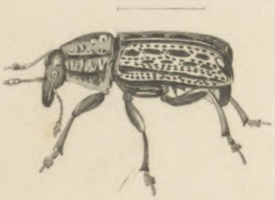
Cantharis vesicatoria.

15.



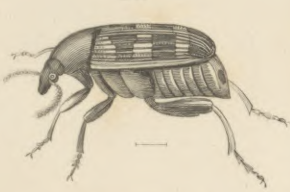
Brentus anchorago.

16.



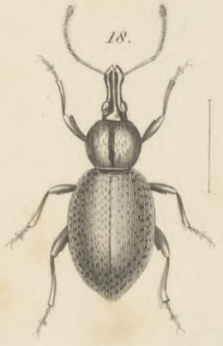
Anthribus latirostris.

17.



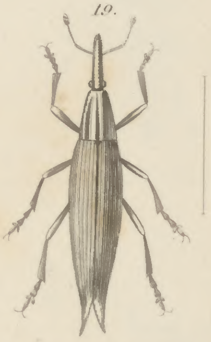
Bruchus pisi.

18.



Curculio ligustici.

19.



Lixus paraplecticus.

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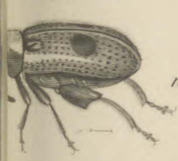
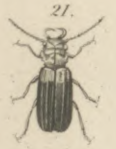


Orchestes alni.

21.



Cucujus mandibularius.

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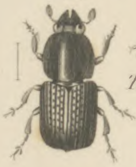

Scolytus Ulmi.

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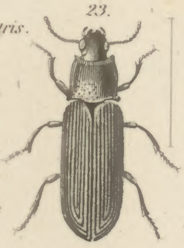
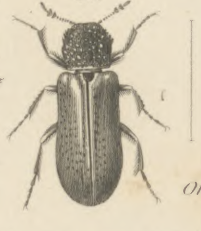


Tenebrio molitor.

24.



Bostrichus capucinus.

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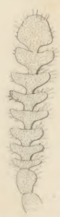
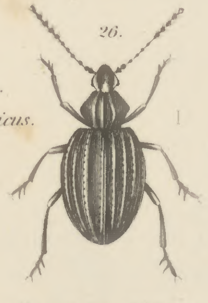


Antenna of Orthocerus muticus.

26.



Dasycerus sulcatus.

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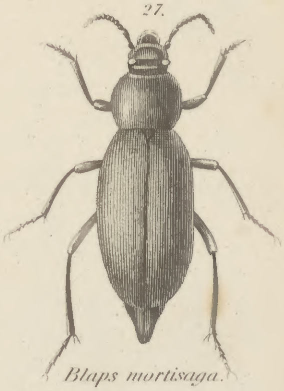

Blaps mortisaga.

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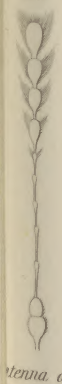
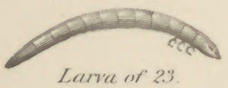


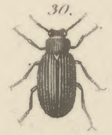
tenna of 26.

29.



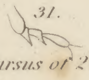
Larva of 23.

30.



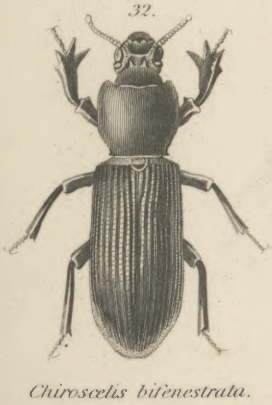
Heterotarsus tenebrioides.

31.



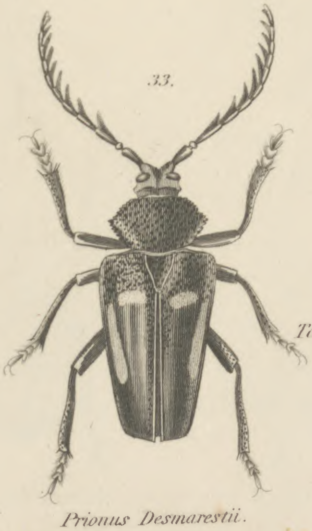
Tarsus of 26.

32.



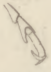
Chiroscelis bifenestrata.

33.



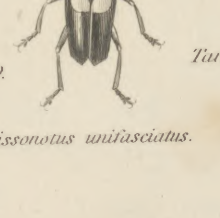
Prionus Desmarestii.

34.



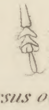
Tarsus of 30.

35.



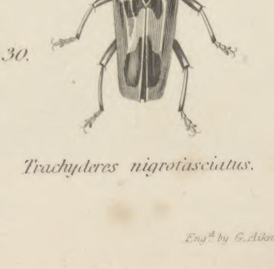
Lissonotus unifasciatus.

36.



Tarsus of 30.

37.



Trachyderes nigrofasciatus.

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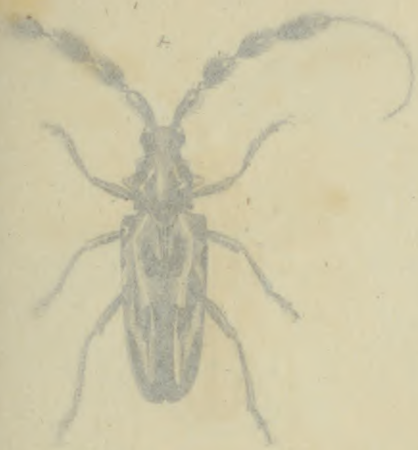
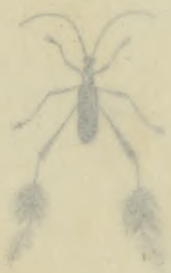
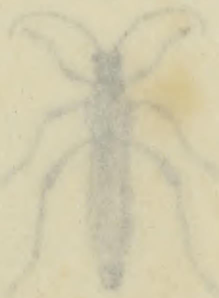

Lophonocerus barbicornis.

2.

Cerambyx [illegible]

3.

Necydalis major.

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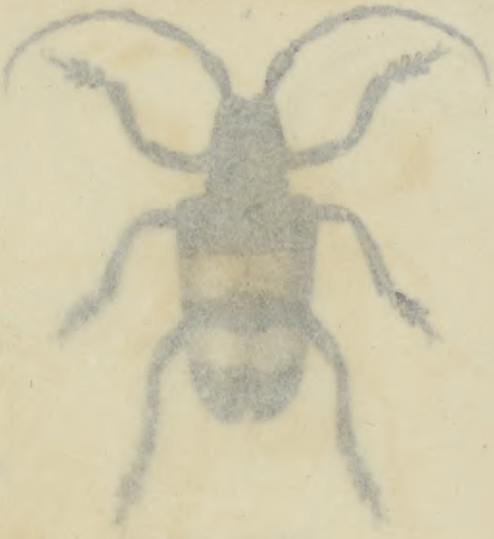
[illegible]

elegans.

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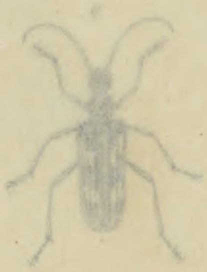
Rhagium bifasciatum.

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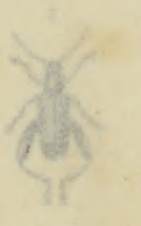
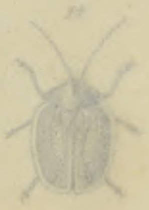

Sagra cyanea.

[illegible]

[illegible]

[illegible]

[illegible]

12.

Cassida longicornis.

13.

Chlamys cuprea.

[illegible]

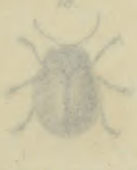
[illegible]

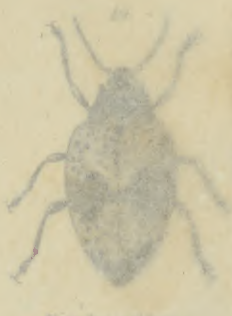
16.

Paropsis [illegible]

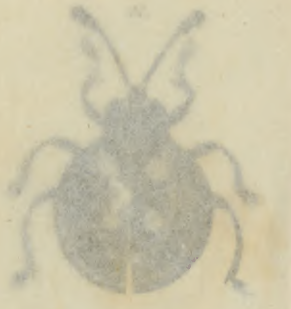
17.

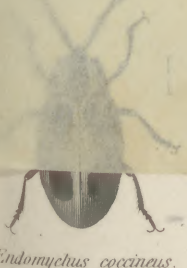
[illegible]

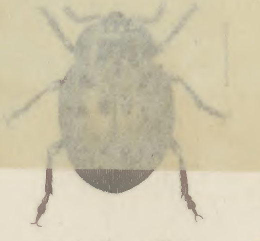
18.

Chrysomela humeralis.

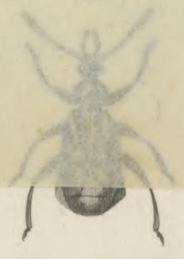
19.

Erotylus gibbosus.

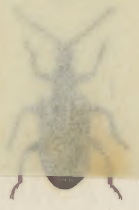
[illegible]

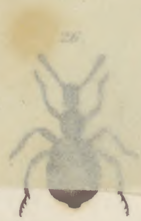
21.

Eumorphus Sumatrensis.

22.

Endomychus coccineus.

23.

Coccinella ocellata.

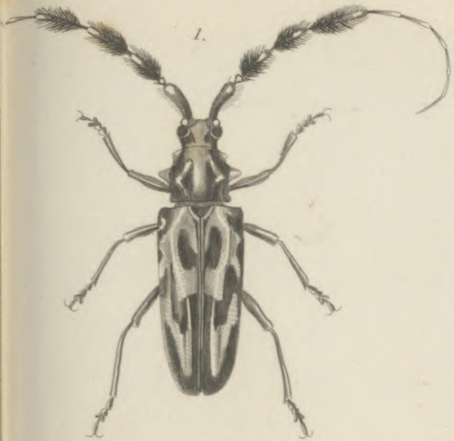
24.

Pselaphus hæmaticus.


Chenium bituberculatum.

26.

Claviger longicornis.

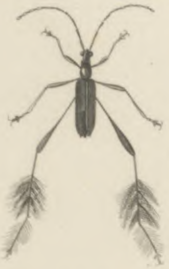
Engd by G. Aikman

1.



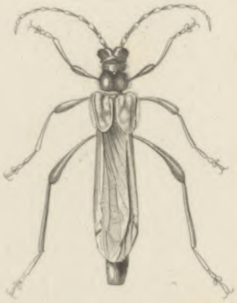
Lophonocerus barbicornis.

2.



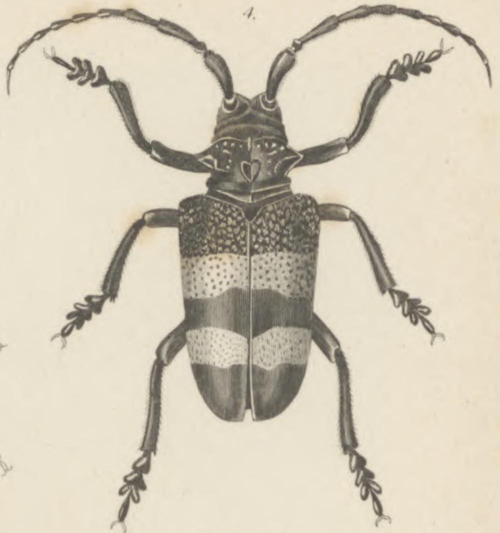
Cerambyx hirtipes.

3.



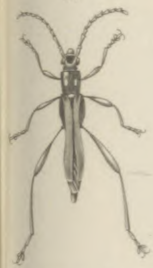
Necydalis major.

4.



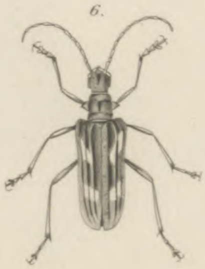
Lamia aurocincta.

5.



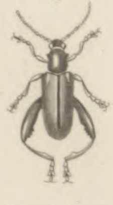
tenopterus elegans.

6.



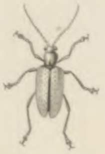
Rhagium bifasciatum.

7.



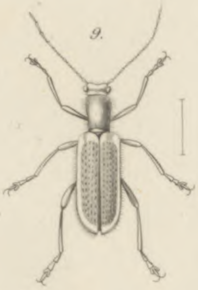
Sagra cyanea.

8.



Donacia fenneca.

9.



Megascelis prasina.

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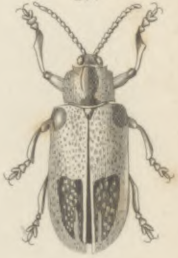
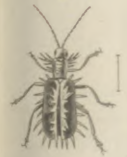


Alurnus corallinus.

11.



Hispa Fabricii.

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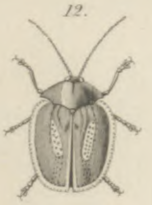
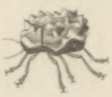


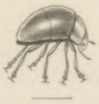
Cassida longicornis.

13.



Chlamys cuprea.

14.



Lamprosoma corrusca.

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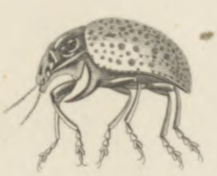
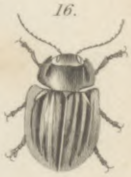


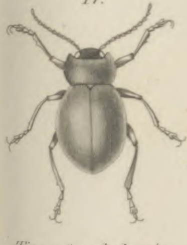
Doryphora multipunctata.

16.



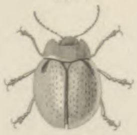
Paropsis 8. lineata.

17.



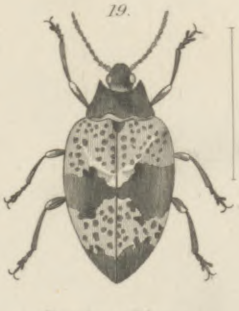
Timarcha balearica.

18.



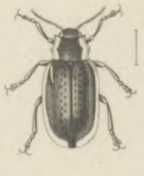
Chrysomela humeralis.

19.



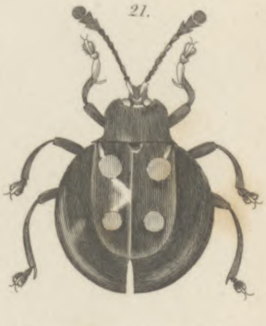
Erotylus gibbosus.

20.



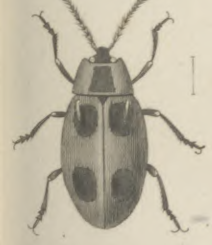
Prasocuris hanoveriana.

21.



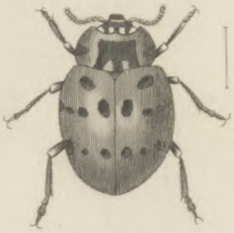
Eumorphus Sumatrensis.

22.



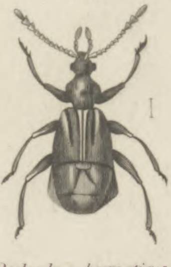
Endomychus coccineus.

23.



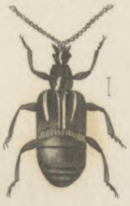
Coccinella ocellata.

24.



Pselaphus hæmaticus.

25.



Chenium bituberculatum.

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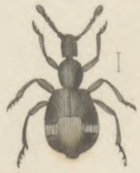
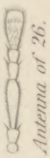


Claviger longicornis.

27.



Antenna of 26.

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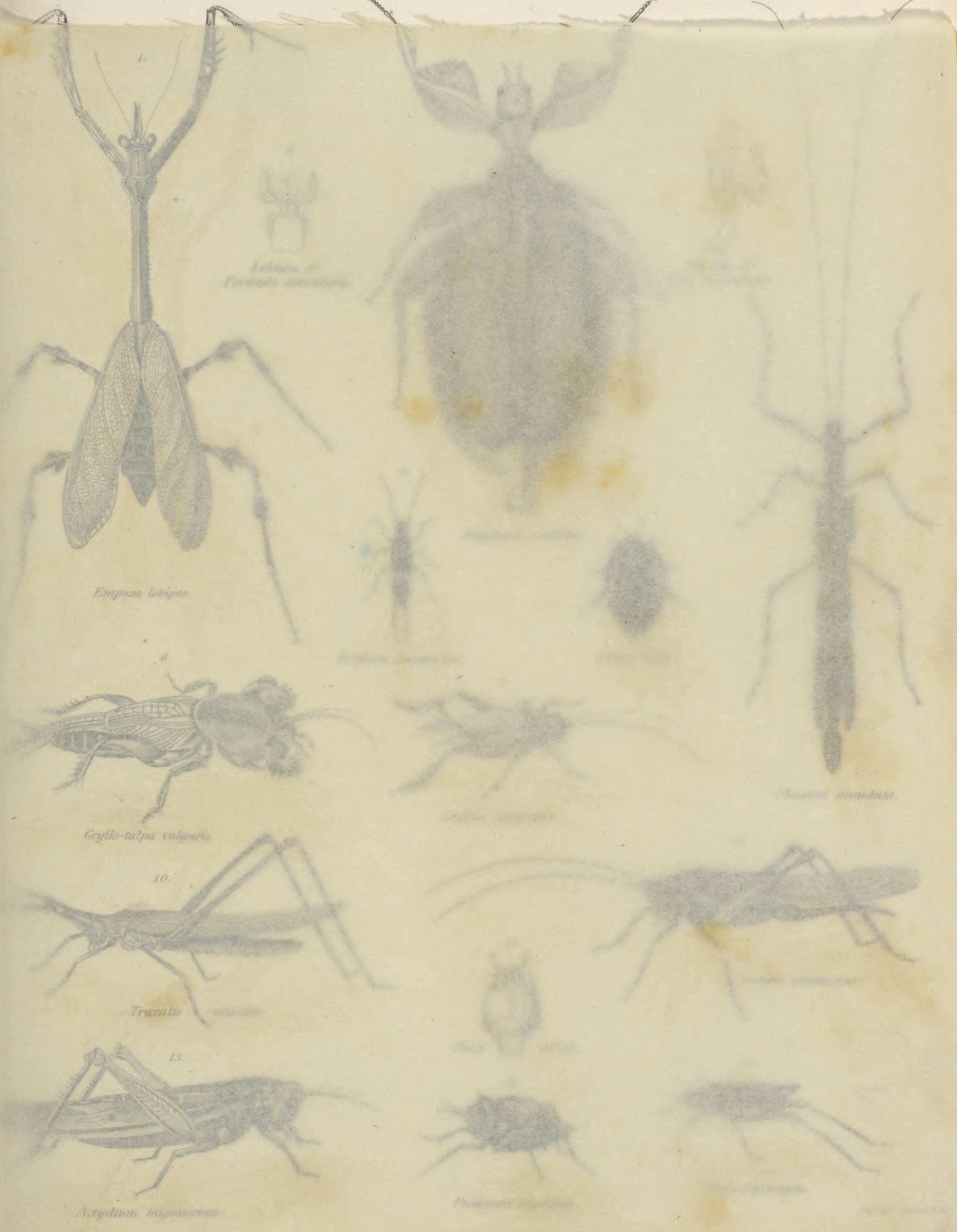
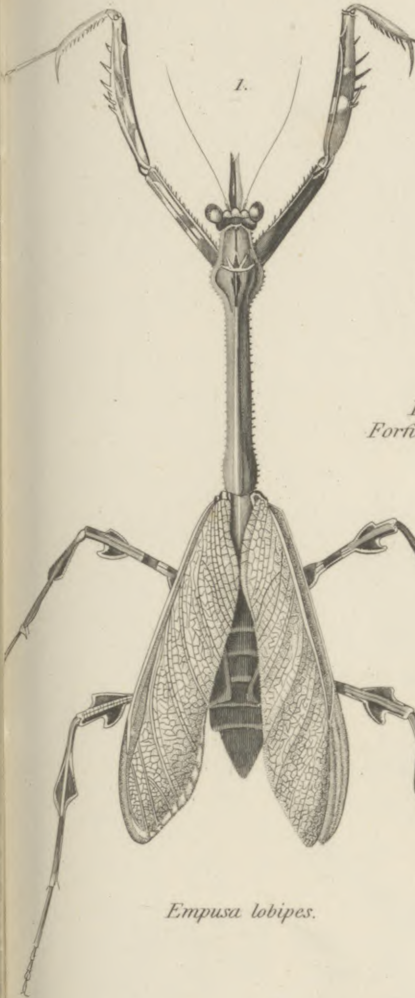
THOPTERA. **ENTOMOLOGY.** *PLATE CCXXVIII.*

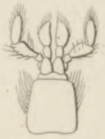


1.



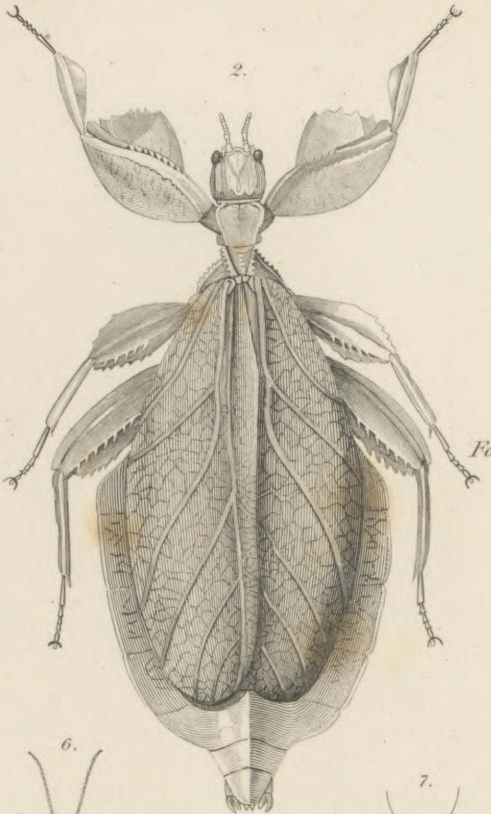
Empusa lobipes.

3.



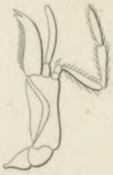
Labium of Forficula auricularia.

2.



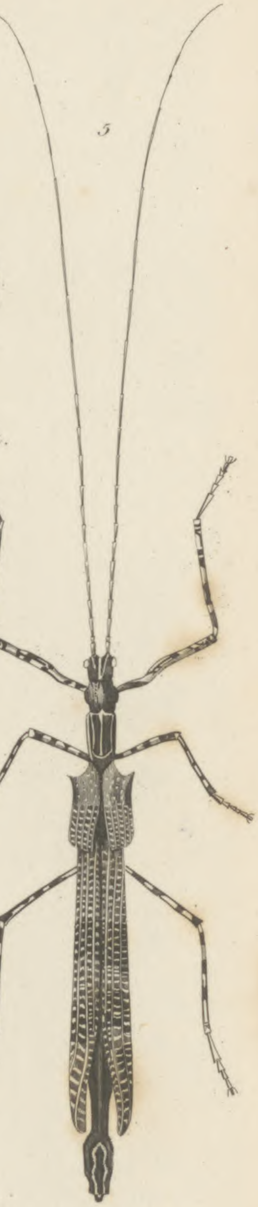
Phyllium siccifolia.

4.



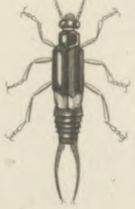
Maxilla of Forf. auricularia.

5



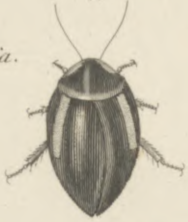
Phasma annulata.

6.



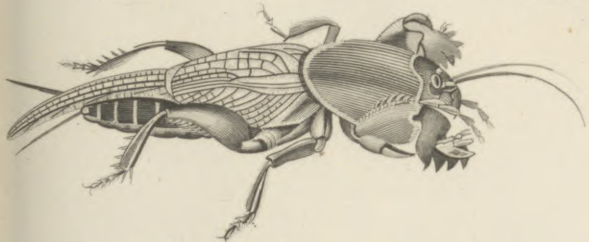
Forficula croceipennis.

7.



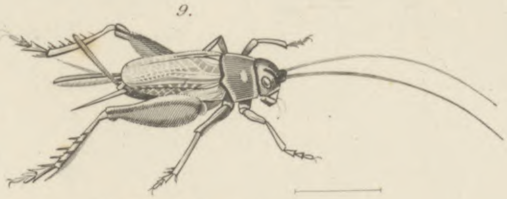
Blatta picta.

8.



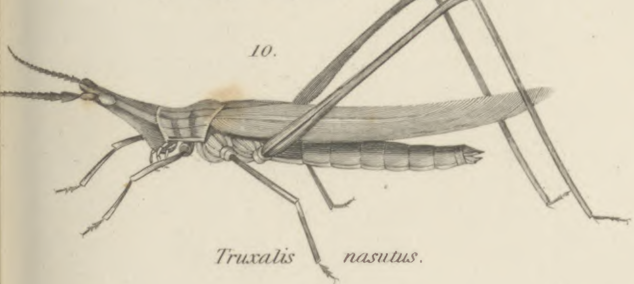
Gryllo-talpa vulgaris.

9.



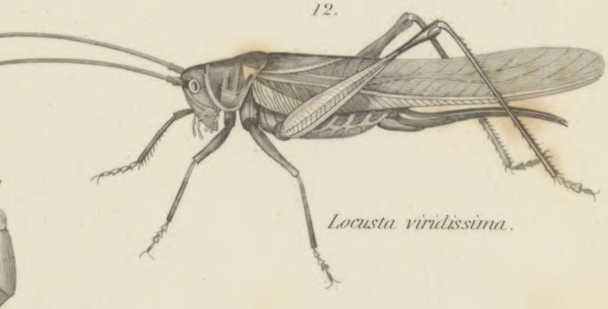
Gryllus domesticus.

10.



Truxalis nasutus.

12.



Locusta viridissima.

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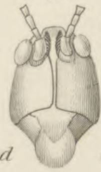
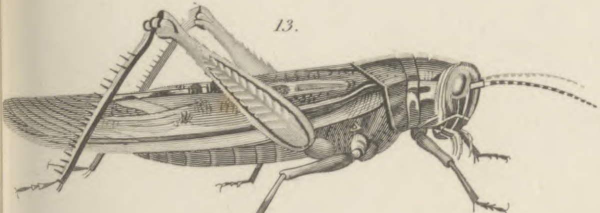


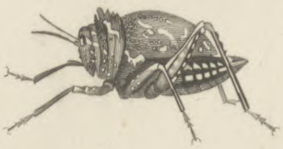
Head of 12.

13.



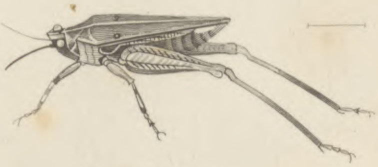
Acrydium migratorium.

14.



Pneumora papillosa.

15.



Tetrix bipunctata.

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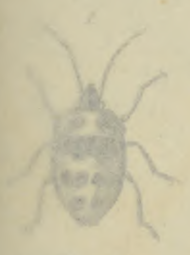
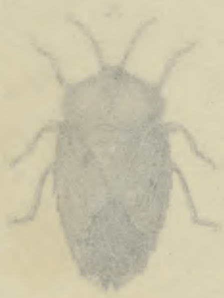
1.



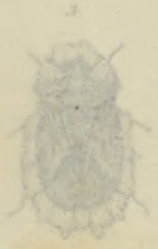
Scutellera Dives.

2.



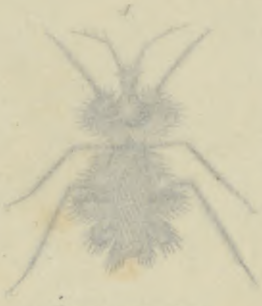
Tesseratoma Sonneratii.

3.



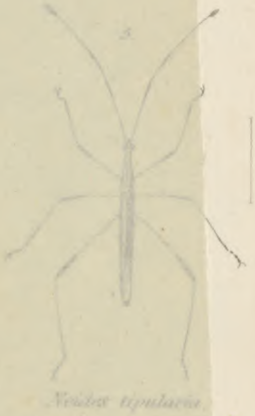
Phloea cassidoides.

4.



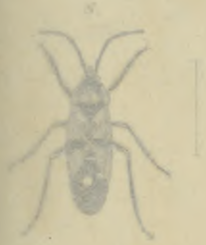
Coreus paradoxus.

5.



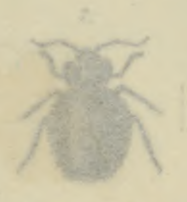
Neides tipularia.

6.



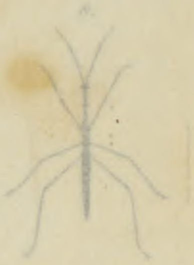
Lygaeus equestris.

7.



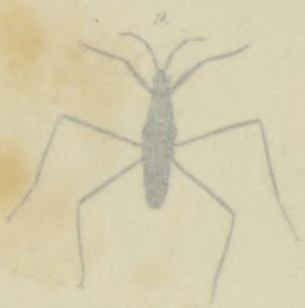
Cimex lectularius.

8.



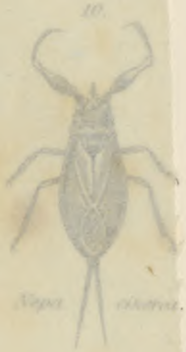
Hydrometra linearis.

9.



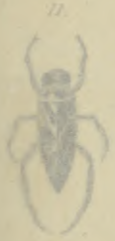
Gerris lacustris.

10.



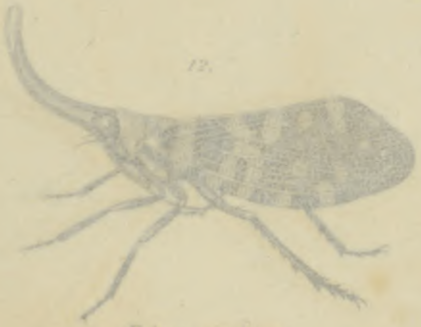
Nepa cinerea.

11.



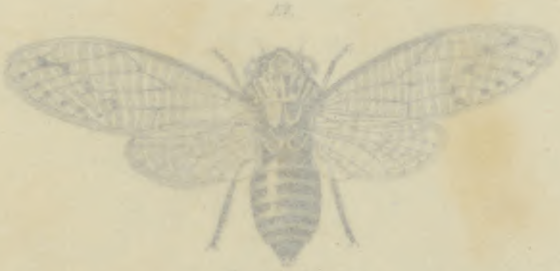
Notonecta glauca.

12.



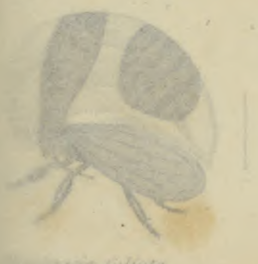
Fulgora candelaria.

13.



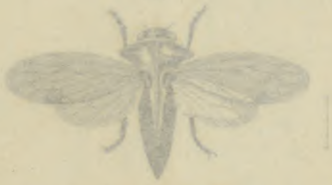
Cicada Fraxini.

14.



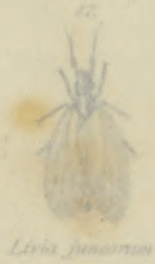
Membracis foliata.

15.



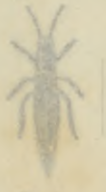
Centrotus cornutus.

17.



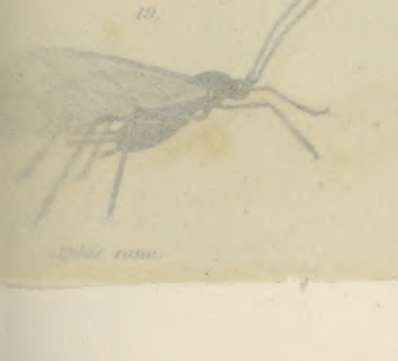
Livia juncorum.

18.



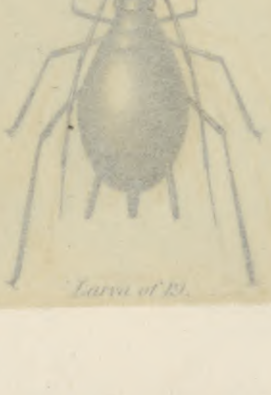
Thrips.

19.



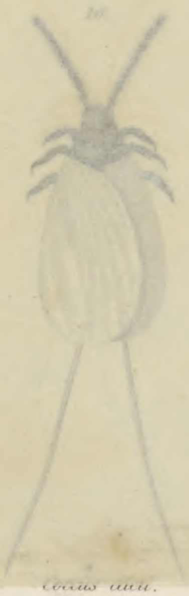
Aphis rosae.

20.



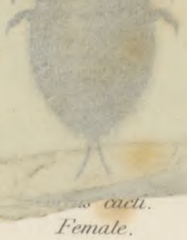
Larva of 19.

16.



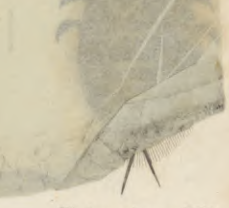
Coccus cacti.
Male.

21.



Coccus cacti.
Female.

22.



Under view of 21.

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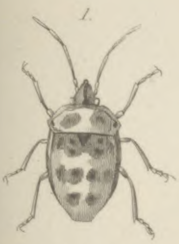
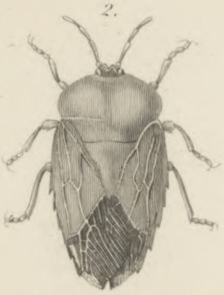
ENTOMOLOGY.

1.



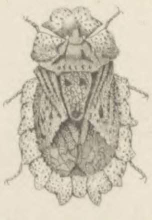
Scutellera Dives.

2.



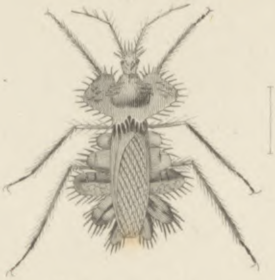
Tesseratoma Sonneratii.

3.



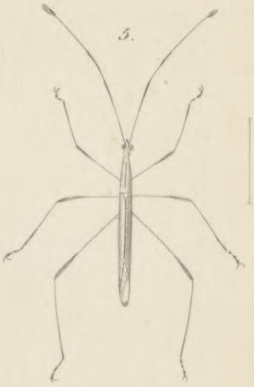
Phlœa cassidoides.

4.



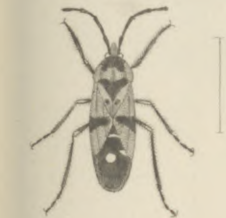
Coreus paradoxus.

5.



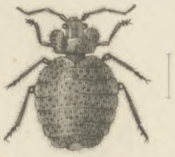
Neides tipularia.

6.



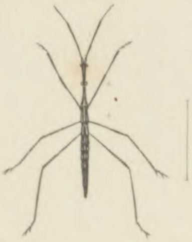
Lygæus equestris.

7.



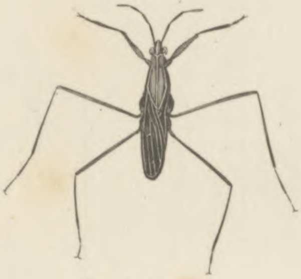
Cimex lectularius.

8.



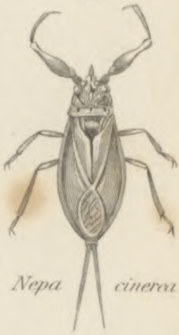
Hydrometra linearis.

9.



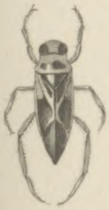
Gerris lacustris.

10.



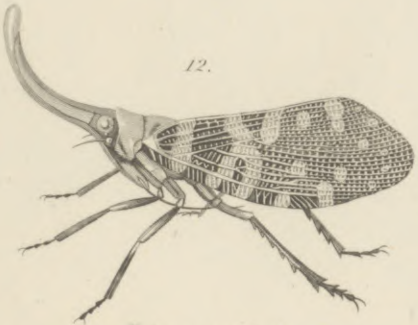
Nepa cinerea.

11.



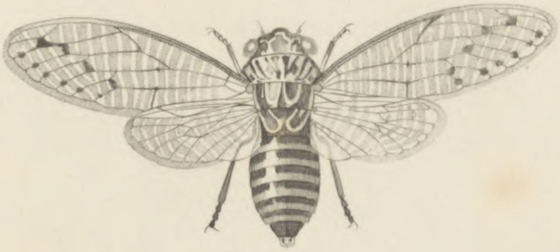
Notonecta glauca.

12.



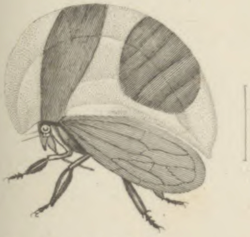
Fulgora candelaria.

13.



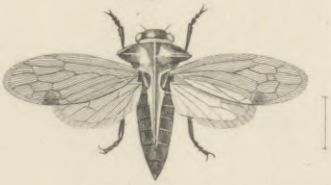
Cicada fraxini.

14.



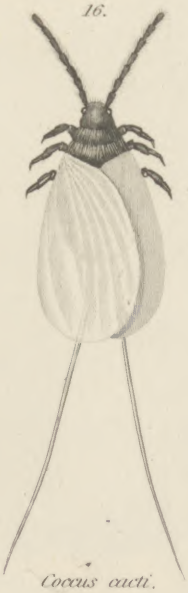
Membracis foliata.

15.



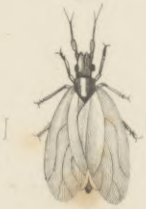
Centrotus cornutus.

16.



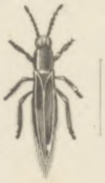
Coccus cacti.
Male.

17.



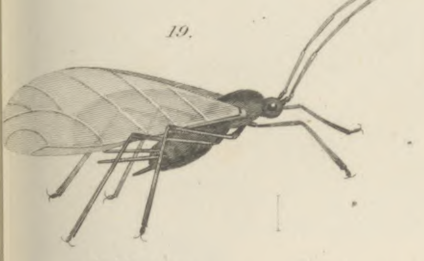
Livia juncorum.

18.



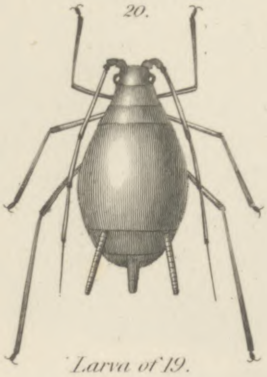
Thrips.

19.



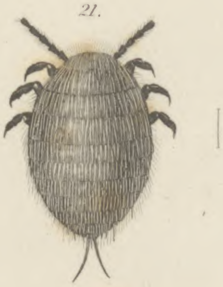
Aphis rosæ.

20.



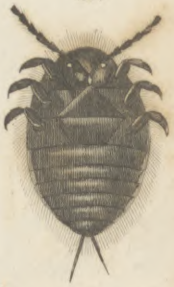
Larva of 19.

21.



Coccus cacti.
Female.

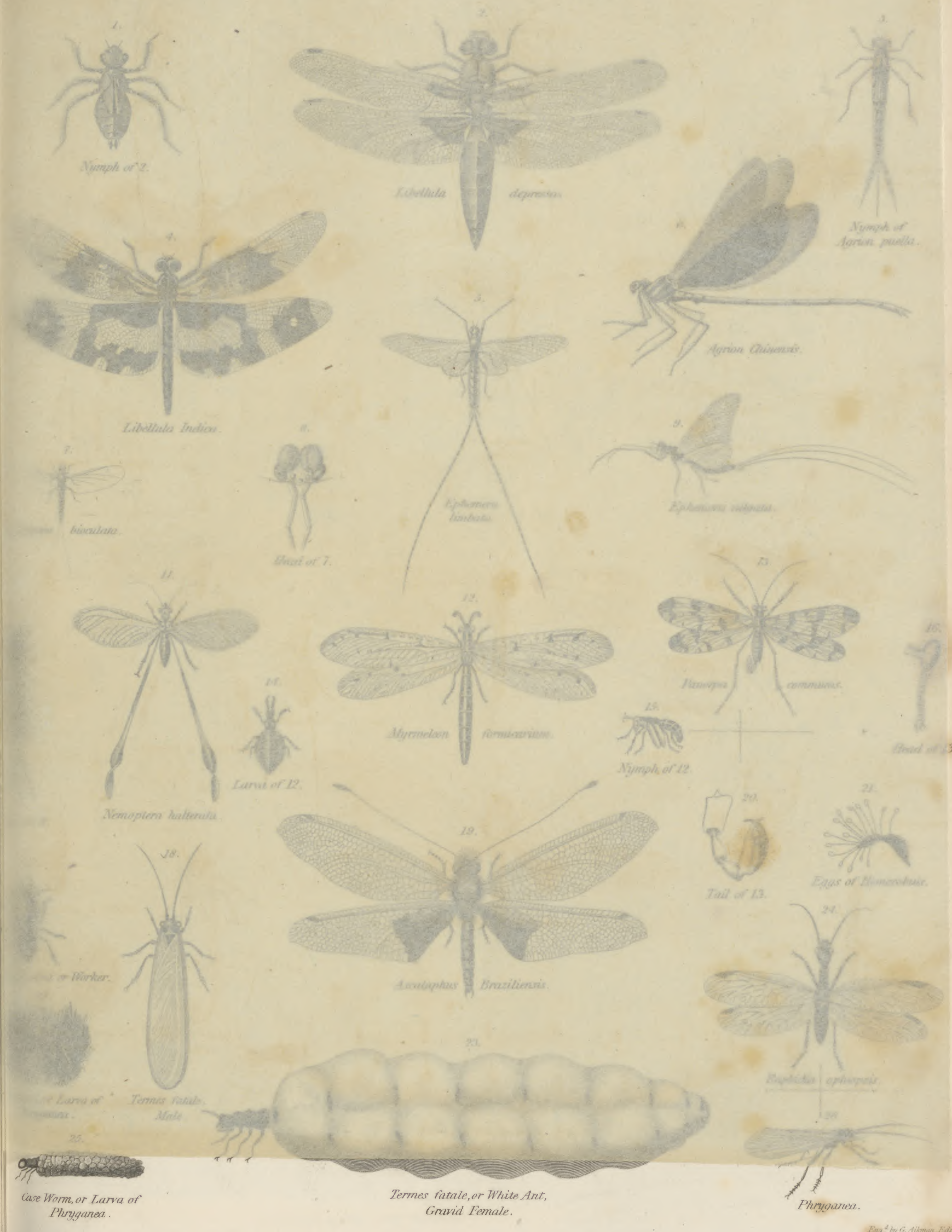
22.



Under view of 21.

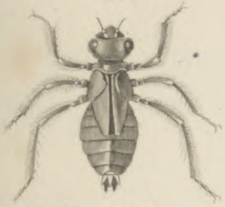
Eng^{d} by G. Aikman, Edin^{r}

OPTERA. **ENTOMOLOGY.** PLATE CCXXI.



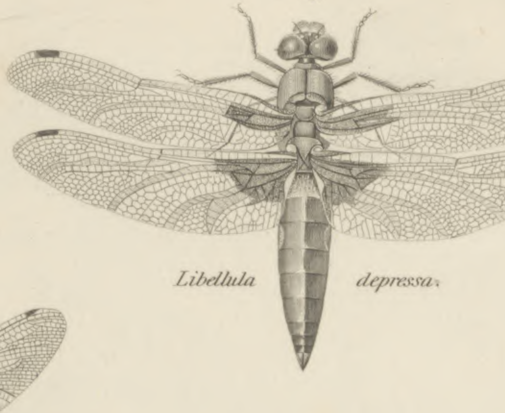
Engd. by G. Aikman. Edinr.

1.



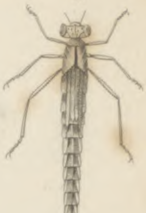
Nymph of 2.

2.



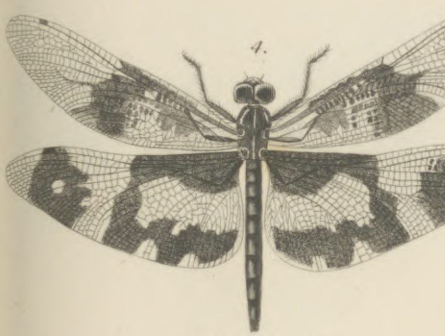
Libellula depressa.

3.



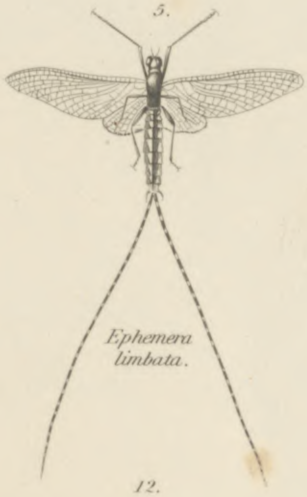
Nymph of Agrion puella.

4.



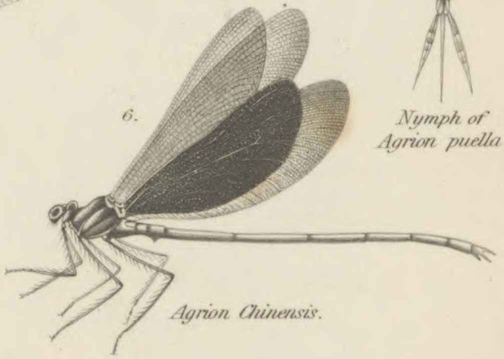
Libellula Indica.

5.



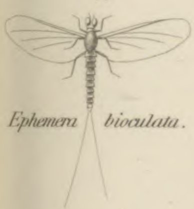
Ephemera limbata.

6.



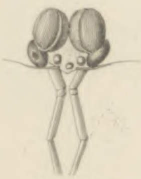
Agrion Chinensis.

7.



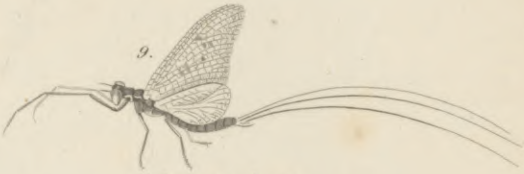
Ephemera bioculata.

8.



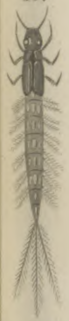
Head of 7.

9.



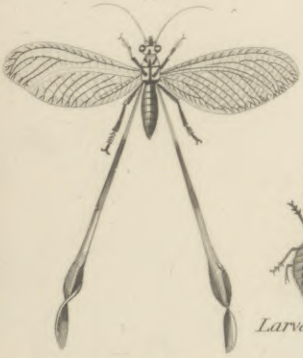
Ephemera vulgata.

10.



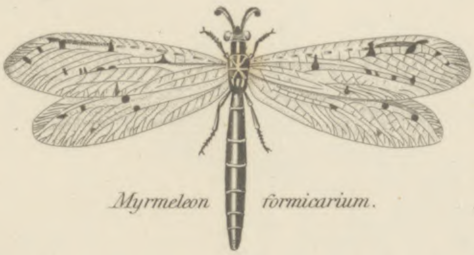
ymph of 9.

11.



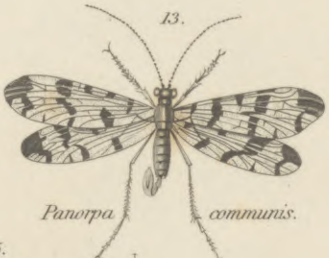
Nemoptera halterata.

12.



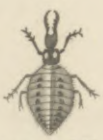
Myrmeleon formicarium.

13.



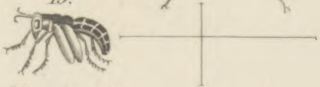
Panorpa communis.

14.



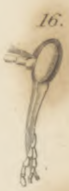
Larva of 12.

15.



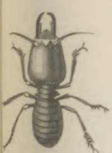
Nymph of 12.

16.



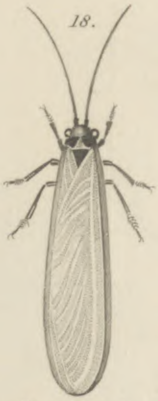
Head of 13.

17.



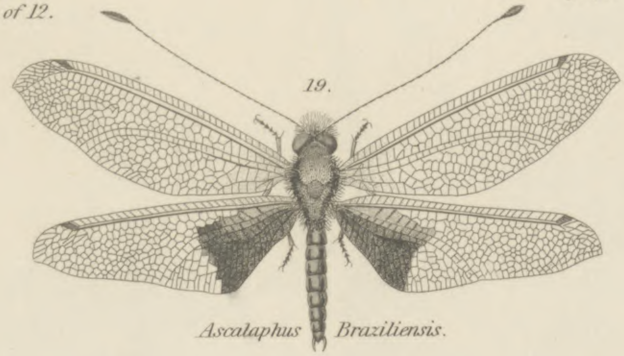
atale, Larva or Worker.

18.



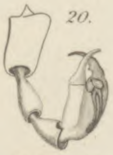
Termes fatale, Male.

19.



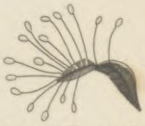
Ascalaphus Braziliensis.

20.



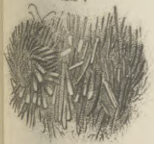
Tail of 13.

21.



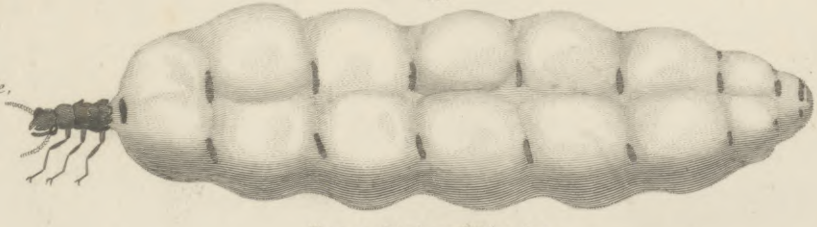
Eggs of Hemerobuis.

22.



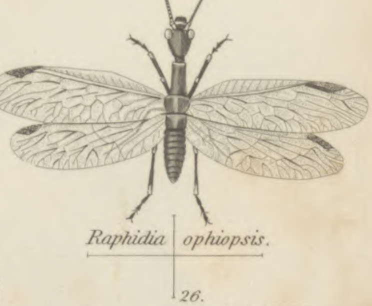
ase Worm, or Larva of Phryganea.

23.



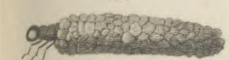
Termes fatale, or White Ant, Gravid Female.

24.



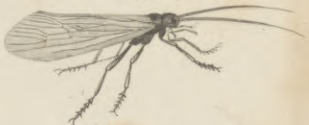
Raphidia ophiopsis.

25.



Case Worm, or Larva of Phryganea.

26.



Phryganea.

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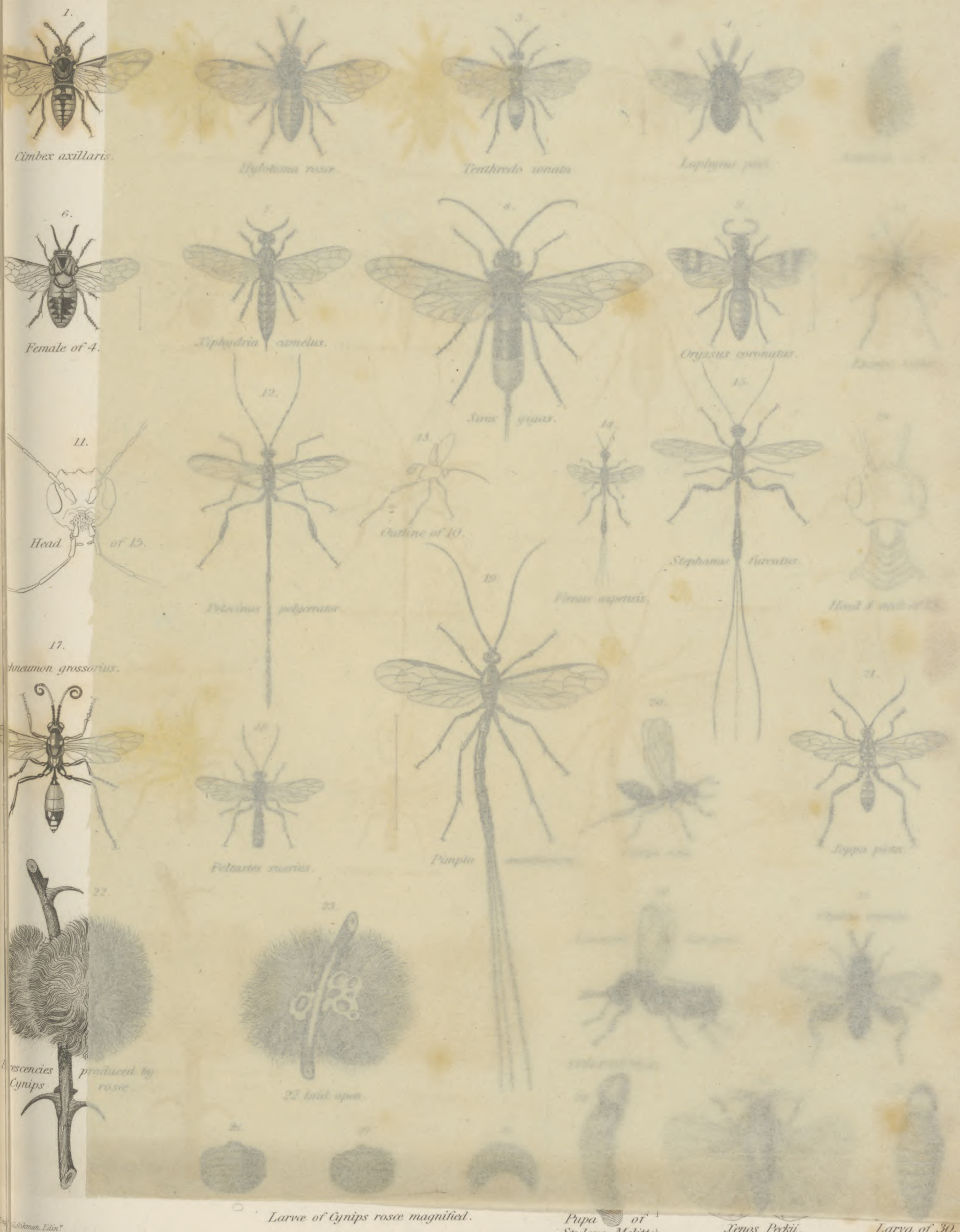


1. Cimbex axillaris.

2. Hylotoma rosæ.

3. Tenthredo zonata.

4. Lophyrus pini.

6. Female of 4.

7. Xiphydria camelus.

8. Sirex gigas.

9. Oryssus coronatus.

11. Head of 15.

12. Pelecinus polycerator.

13. Outline of 10.

14.

15. Stephanus furcatus.

17. chneumon grossorius.

19. Pimpla

21. Joppa picta.

22. escencies produced by Cynips rosæ.

23. 22 laid open.

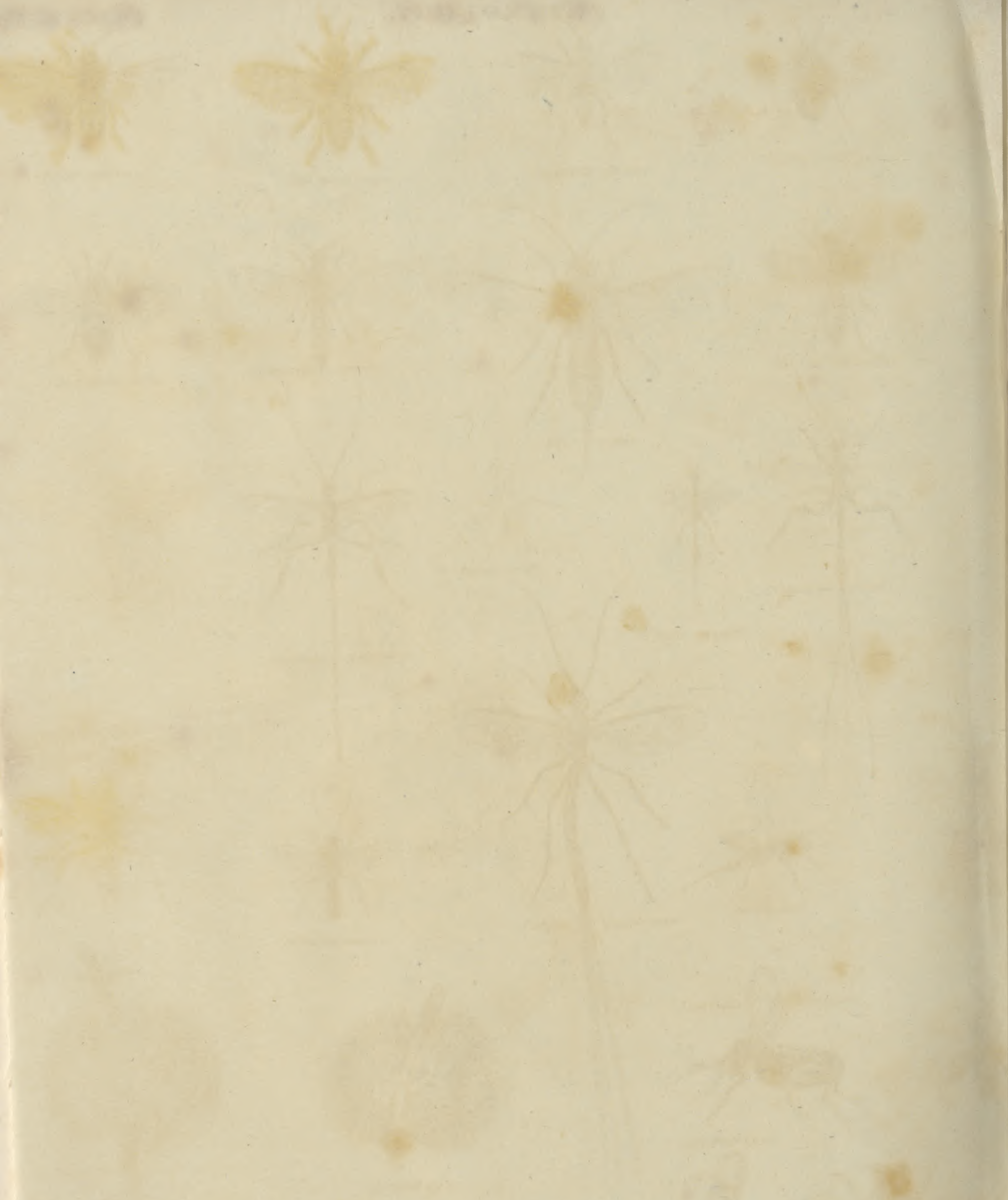
Larvæ of Cynips rosæ magnified.

Pupa of Stylops Melittæ.

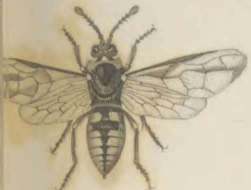
Xenos Peckii.

Larva of 30.

Engd by Aikman. Edinr.

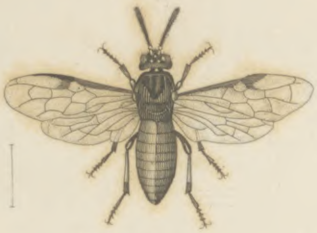


1.



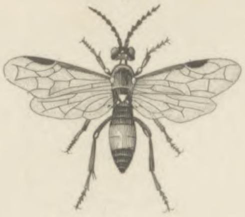
Cimbex axillaris.

2.



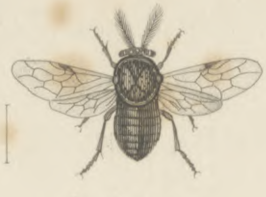
Hylotoma rosæ.

3.



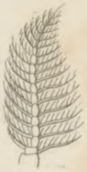
Tenthredo zonata.

4.



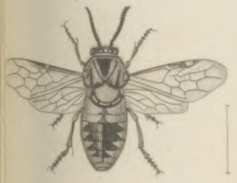
Lophyrus pini.

5.



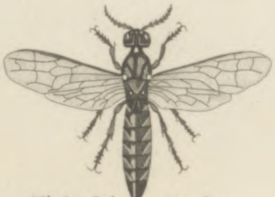
Antenna of 4.

6.



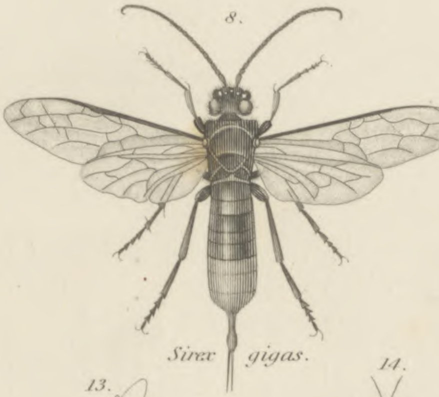
Female of 4.

7.



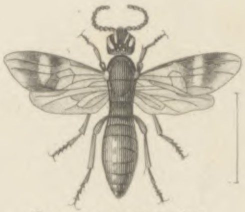
Xiphydria camelus.

8.



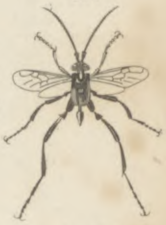
Sirex gigas.

9.



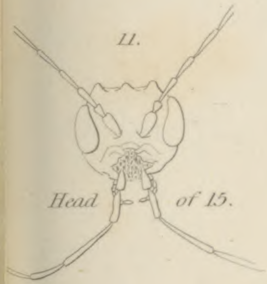
Oryssus coronatus.

10.



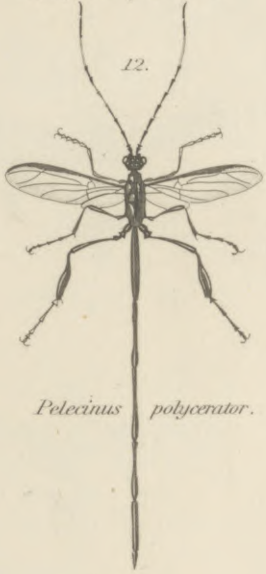
Evania Cubæ.

11.



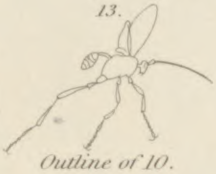
Head of 15.

12.



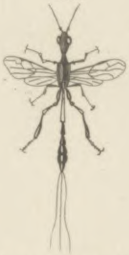
Pelecinus polycerator.

13.



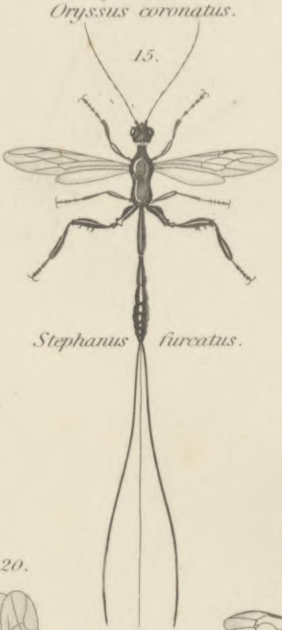
Outline of 10.

14.



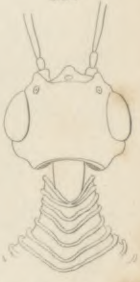
Fænus capensis.

15.



Stephanus furcatus.

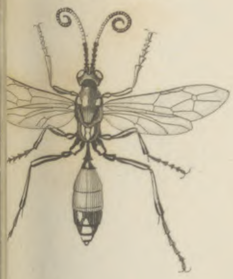
16.



Head & neck of 15.

17.

Ichneumon grossorius.



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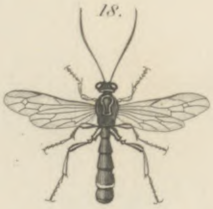
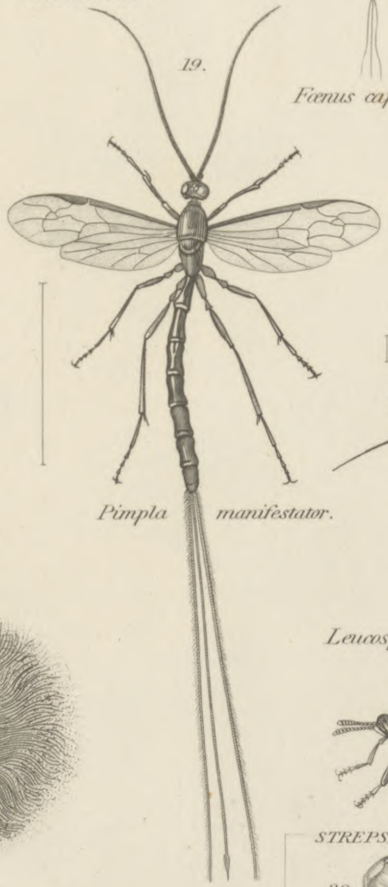


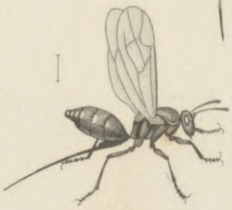
Peltastes suarius.

19.



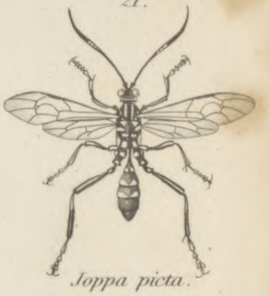
Pimpla manifestator.

20.



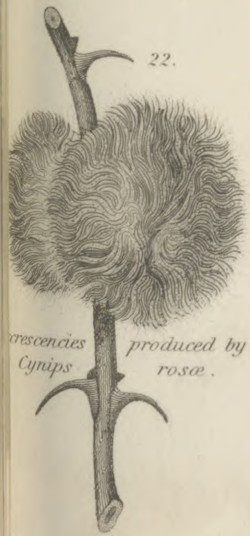
Cynips rosæ.

21.



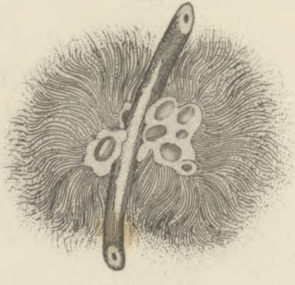
Joppa picta.

22.



crescencies produced by Cynips rosæ.

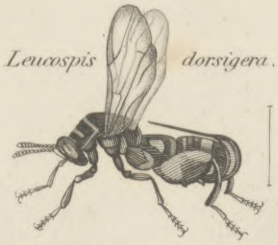
23.



22 laid open.

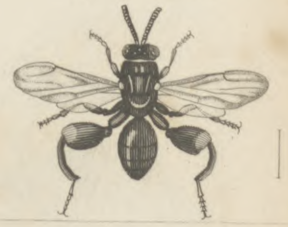
24.

Leucospis dorsigera.

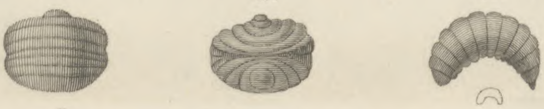


25.

Chalcis minuta.



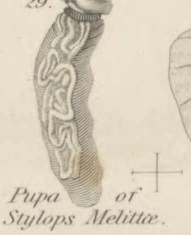
26. 27. 28.



Larvæ of Cynips rosæ magnified.

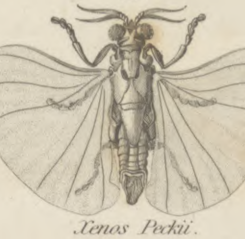
STREPSIPTERA.

29.



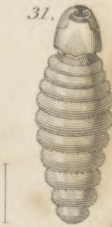
Pupa of Stylops Melittæ.

30.



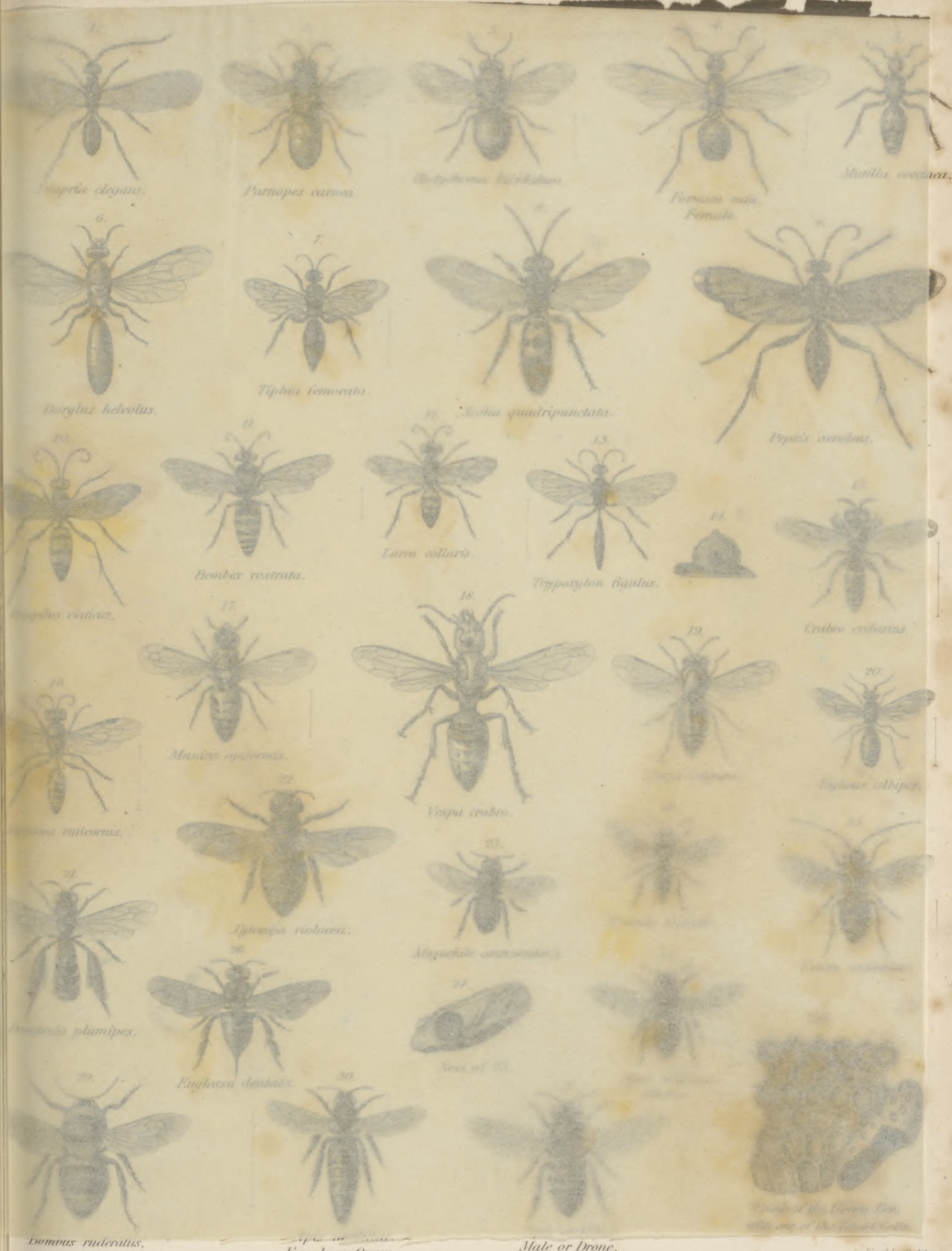
Xenos Peckii.

31.



Larva of 30.

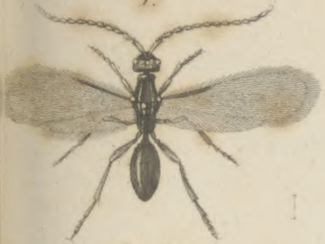
y G.Aikman. Edin.r



Eng^d by G. Aikman, Edin.

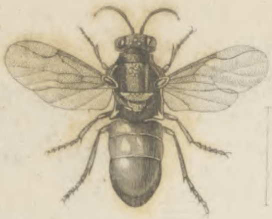
ENTOMOLOGY.

1.



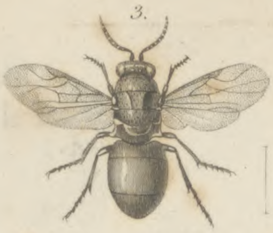
Diapria elegans.

2.



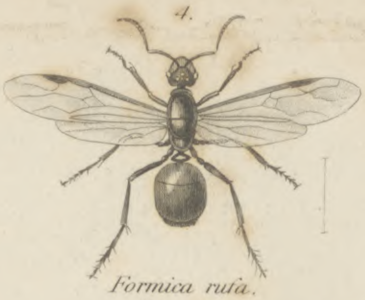
Parnopes carnea.

3.



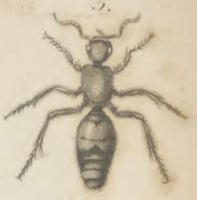
Hedychrum lucidulum.

4.



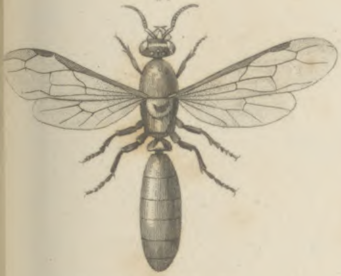
Formica rufa.
Female.

5.



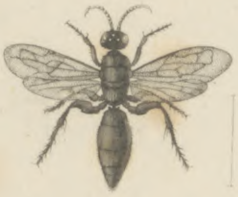
Mutilla coccinea.

6.



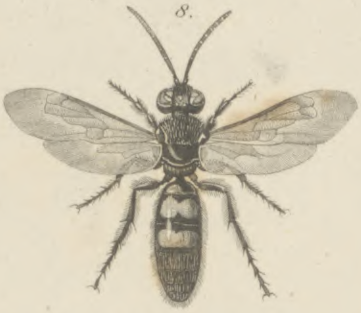
Dorylus helvolus.

7.



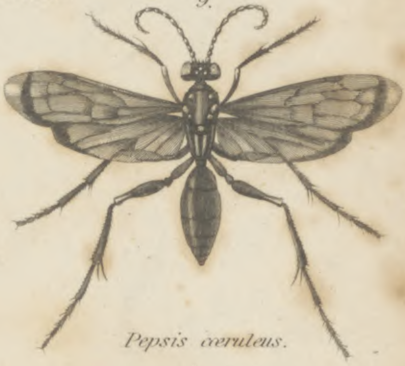
Tiphia femorata.

8.



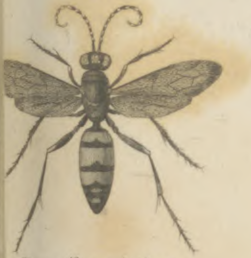
Scolia quadripunctata.

9.



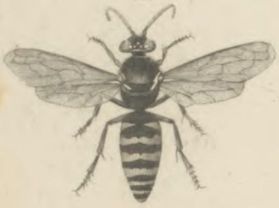
Pepsis cœruleus.

10.



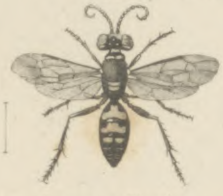
Pompilus viaticus.

11.



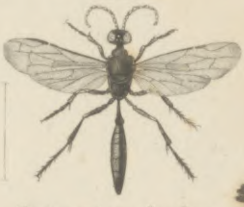
Bembex rostrata.

12.



Larra collaris.

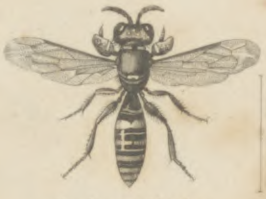
13.



Trypoxylon figulus.

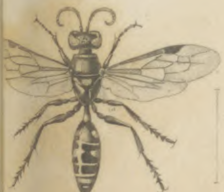
14.

15.



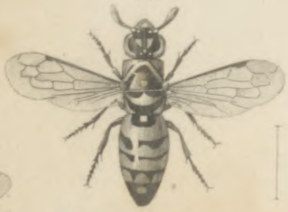
Crabro cribarius.

16.



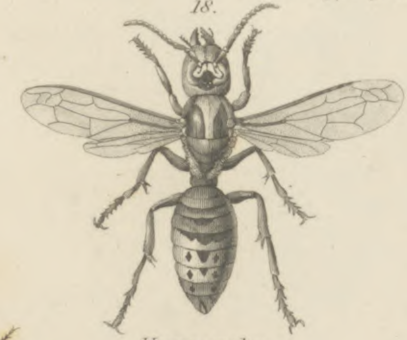
Mellinus ruficornis.

17.



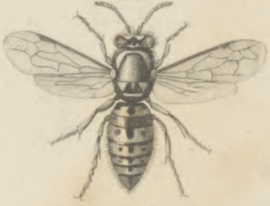
Masaris apiformis.

18.



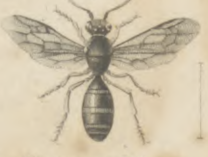
Vespa crabro.

19.



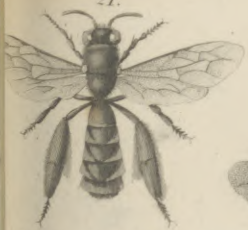
Vespa vulgaris.

20.



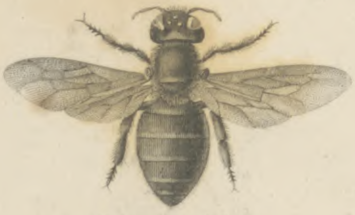
Hylæus albipes.

21.



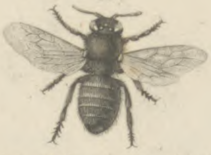
Dasypoda plumipes.

22.



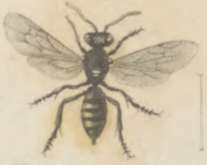
Xylocopa violacea.

23.



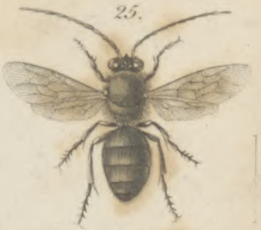
Megachile centuncularis.

24.



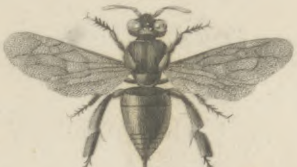
Nomada miniata.

25.



Eucera antennata.

26.

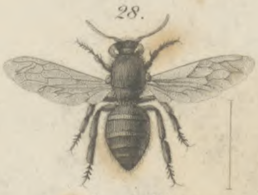


Euglossa dentata.

27.

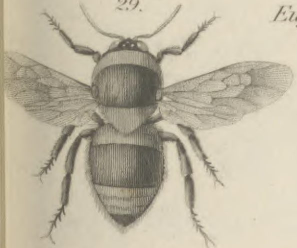
Nest of 23.

28.



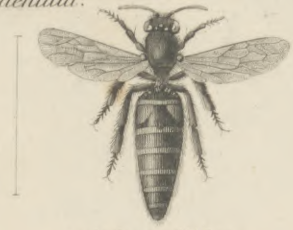
Apis mellifica.
Worker.

29.



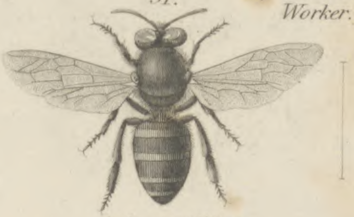
Bombus ruderatus.

30.



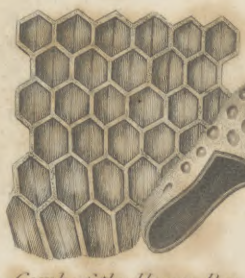
Apis mellifica.
Female or Queen.

31.



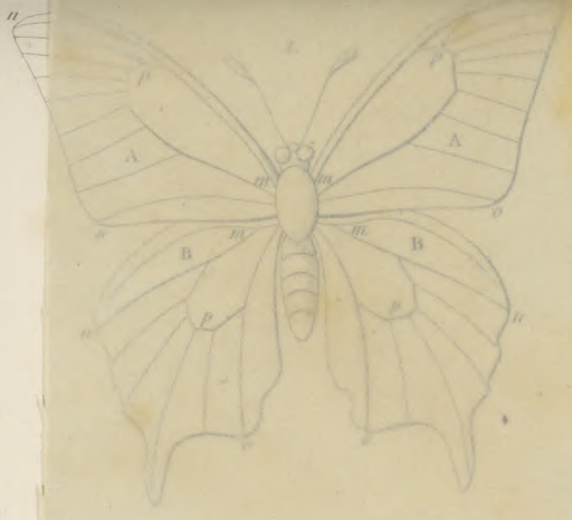
Apis mellifica.
Male or Drone.

32.



Comb of the Honey Bee,
with one of the Royal Cells.

Engd by G. Aikman, Edin



Papilio Machaon.

Parnassius Apollo.

[illegible]

[illegible]

Pieris [illegible]

[illegible]

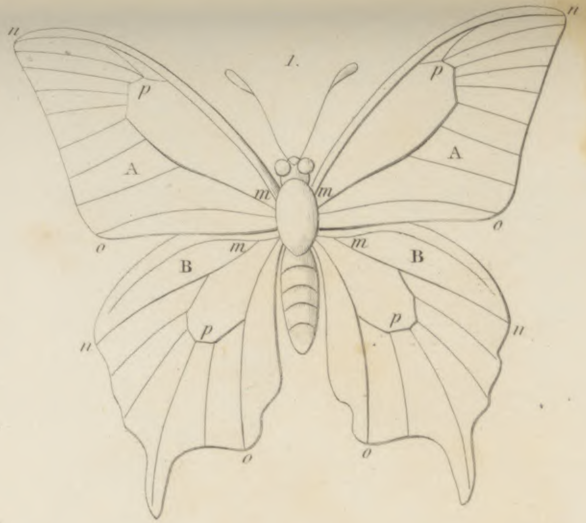
Larva and Chrysalis of
Vanessa Io.

Danaida eunice.

Vanessa Io.

Engd. by G. Aikman, Edinr.

1.



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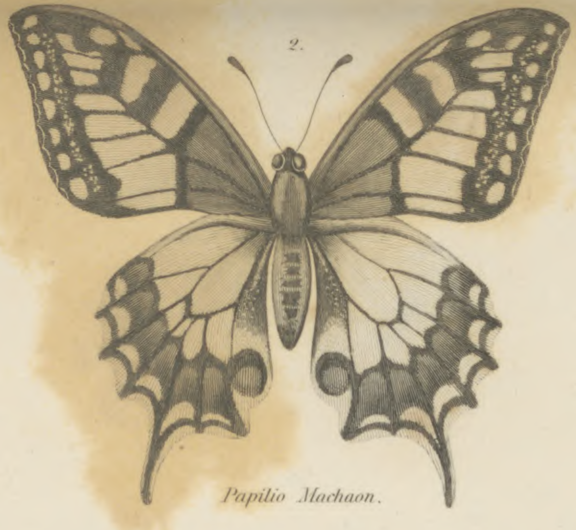
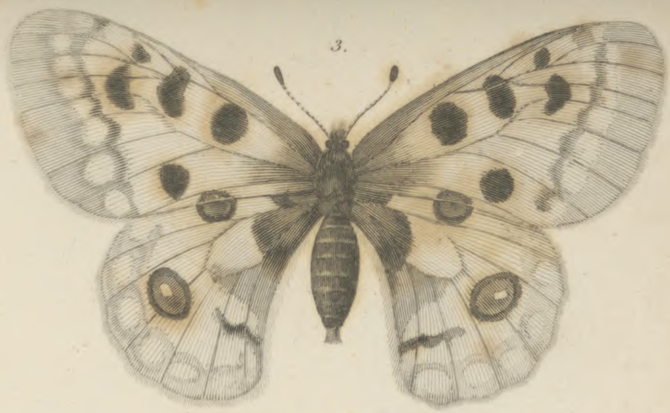


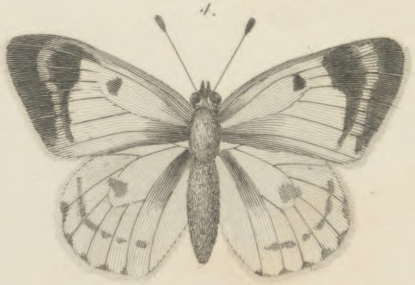
Papilio Machaon.

3.



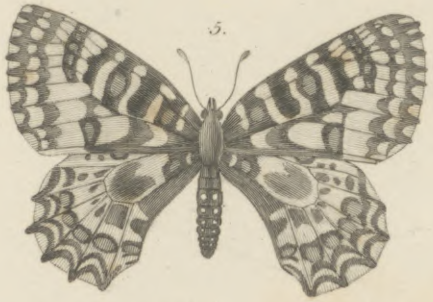
Parnassius Apollo.

4.



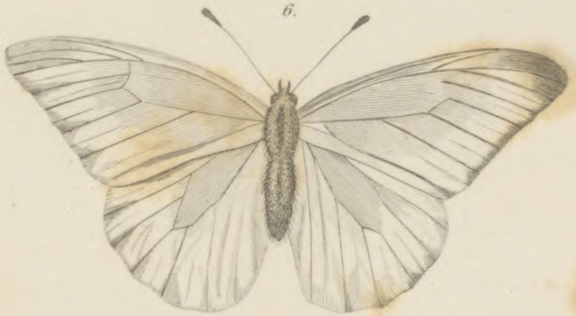
Colias Hyale.

5.



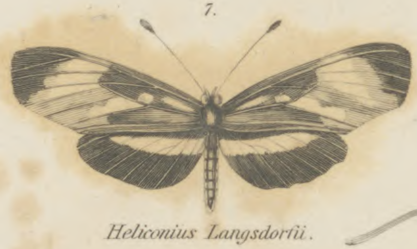
Thais Medesicaste.

6.



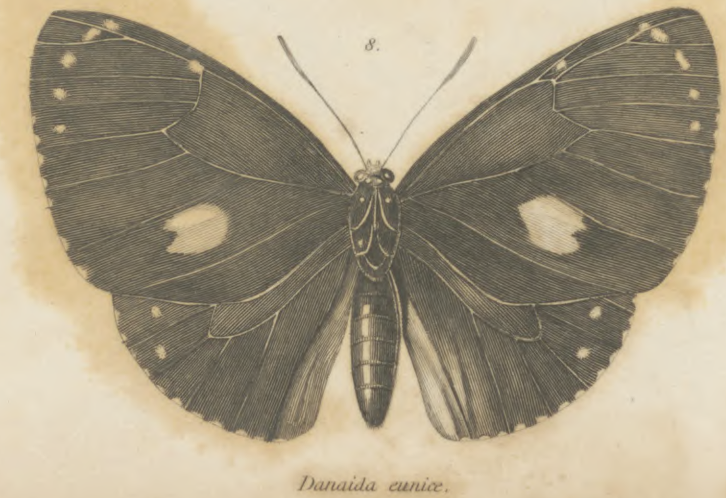
Pieris thiria.

7.



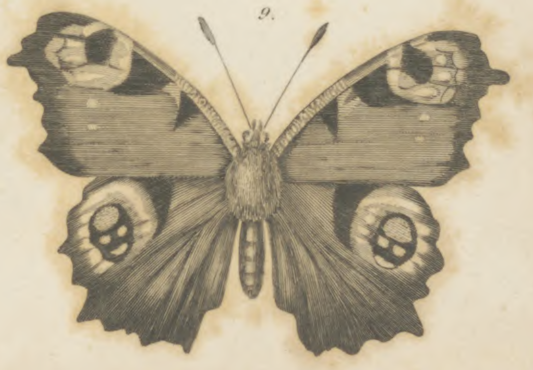
Heliconius Langsdorfii.

8.



Danaida eunice.

9.



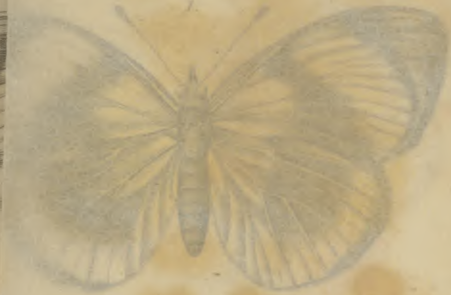
Vanessa Io.

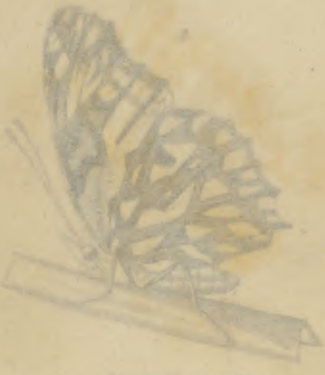
10.

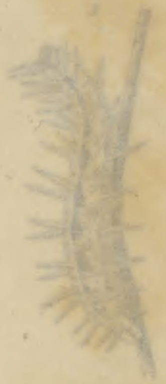
11.

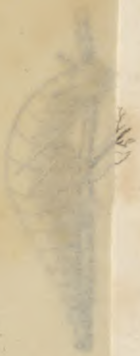
Larva and Chrysalis of
Vanessa Io.

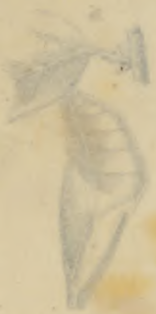
Eng^{d} by G. Aikman, Edin^{r}.

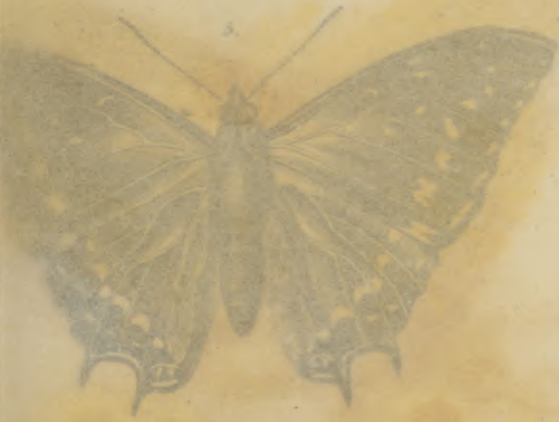

1. Vanessa callithea.

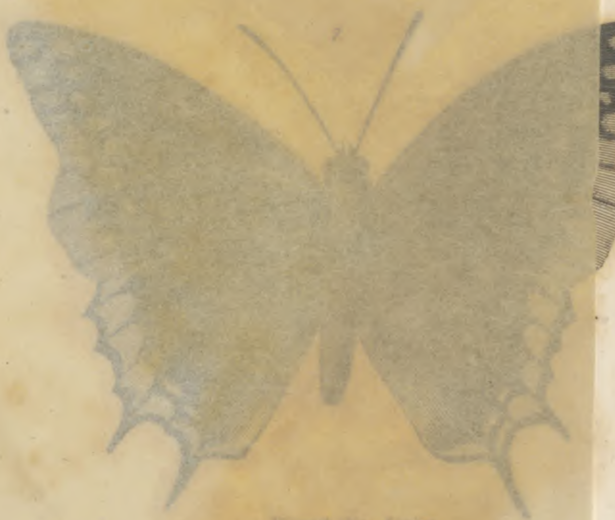

2. Argynnis moneta.

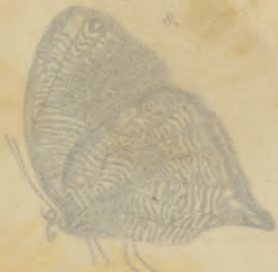

3. Larva of Argynnis paphia.

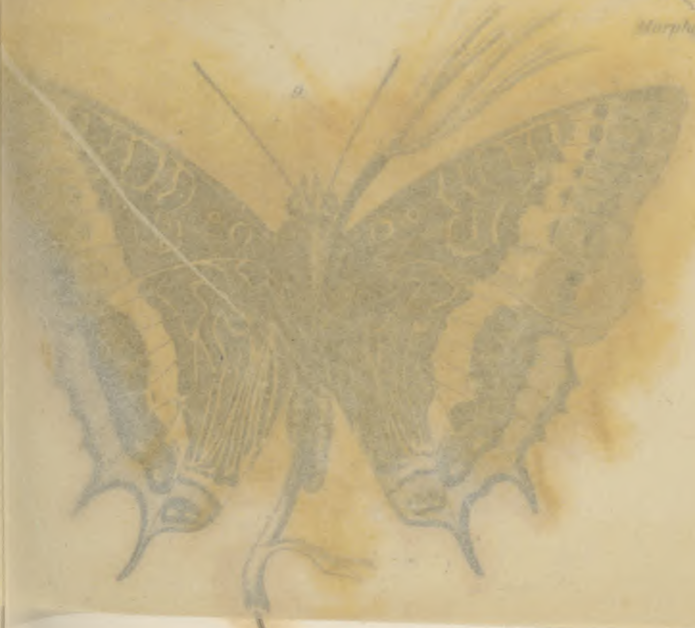

4. Larva of Nymphalis ilia.

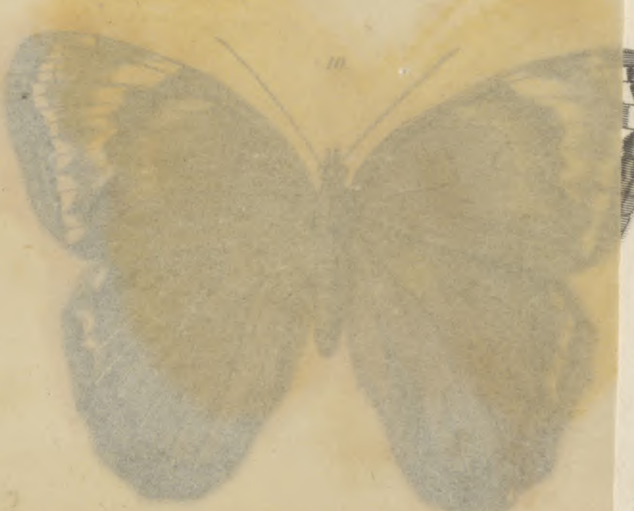

6. Chrysalis of Nymphalis ilia.


5. Nymphalis ethea.


7. Nymphalis Jasius.


8. Morpho neaerion.


9. Nymphalis Jasius.


10. Pavonia acontius.

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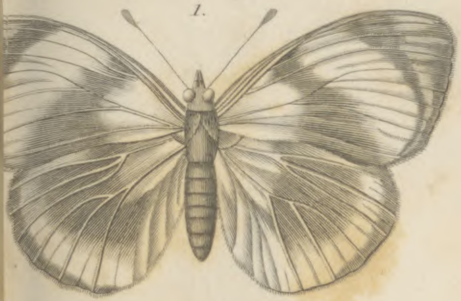
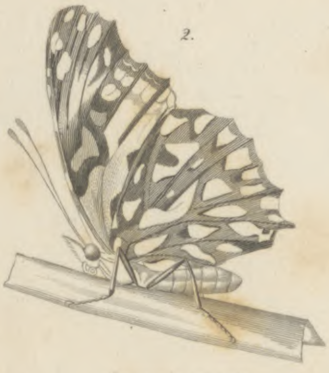
1.



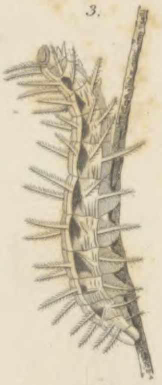
Vanessa callithea.

2.



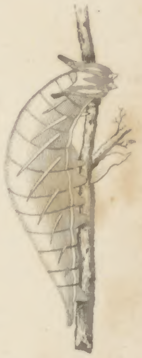
Argynnis moneta.

3.



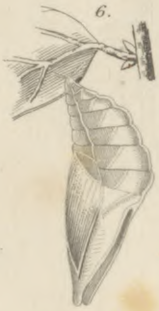
Larva of
Argynnis paphia.

4.



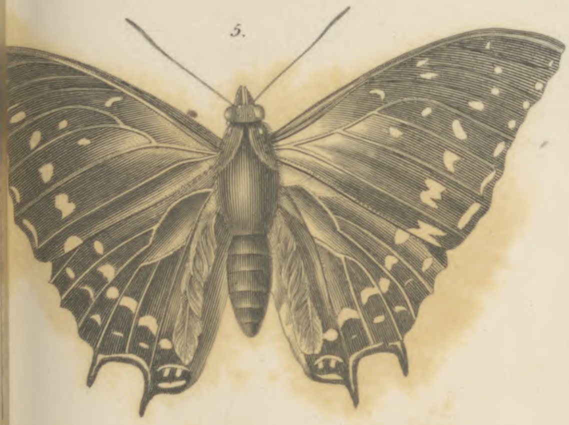
Larva of
Nymphalis ilia.

6.



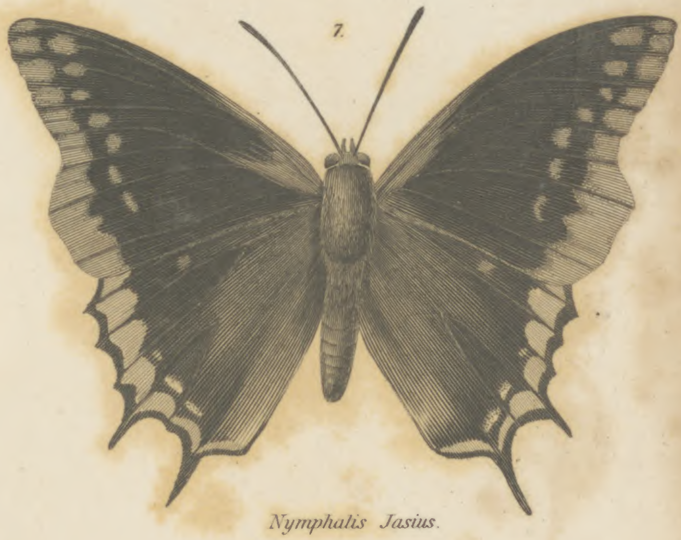
Chrysalis of
Nymphalis ilia.

5.



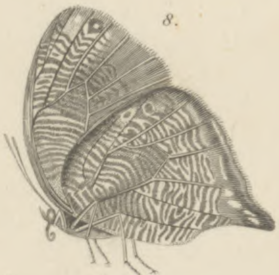
Nymphalis ethea.

7.



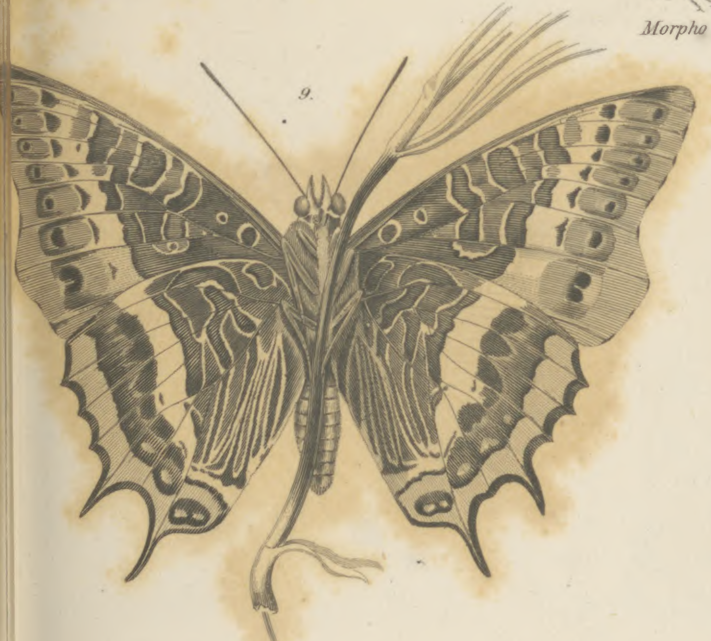
Nymphalis Jasius.

8.



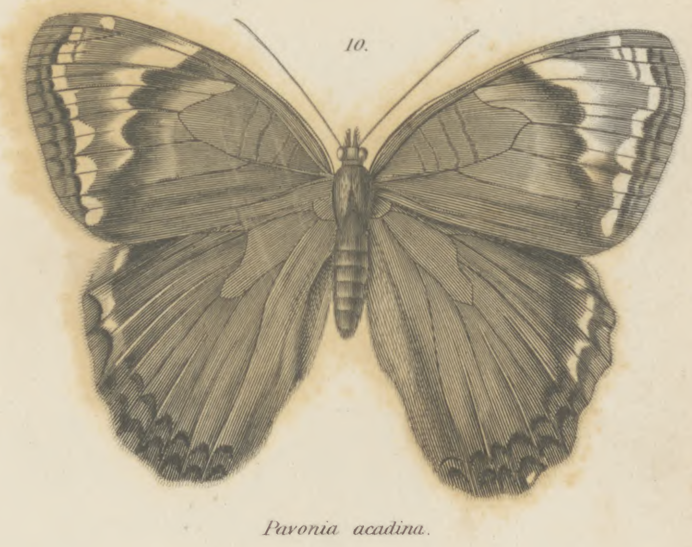
Morpho actorion.

9.



Nymphalis Jasius.

10.

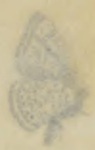


Pavonia acadina.

Eng^{d} by G. Aikman Edin^{r}

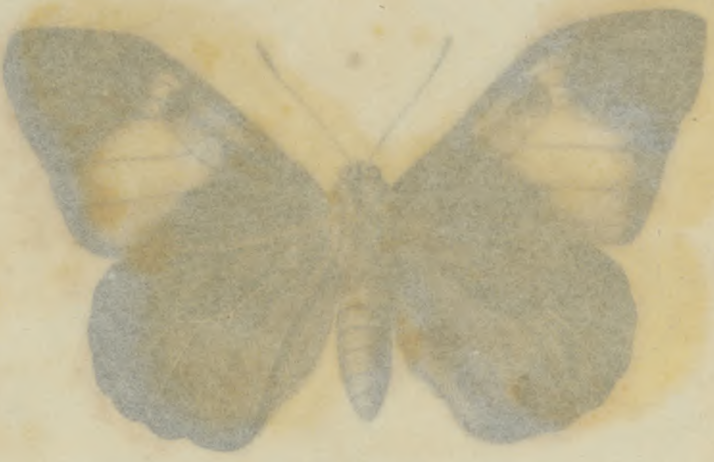
Morpho phidippus.

2.



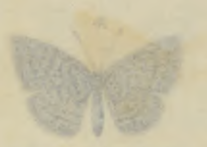
Eryana virginiensis

3.



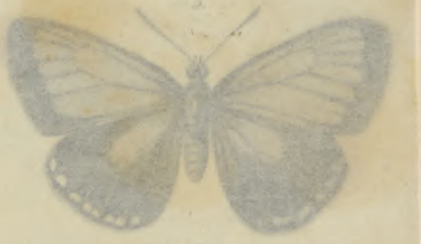
Brassolis astyra

4.



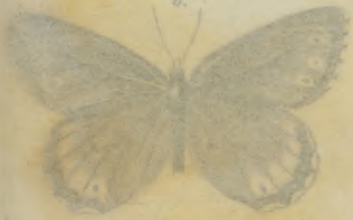
Erycina virginiensis.

5.



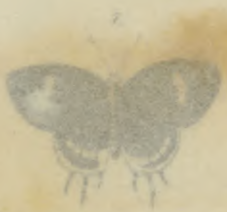
Eumenia toxea.

6.



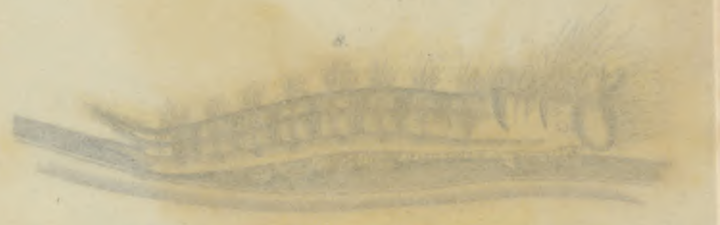
Satyrus Balder.

7.



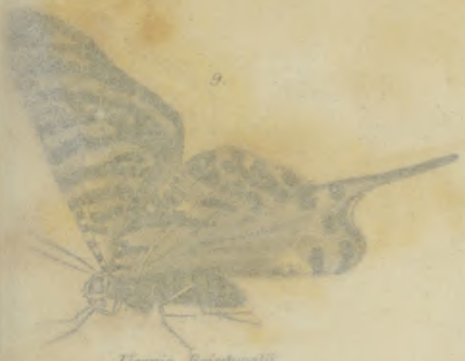
Zephyrius amor.

8.



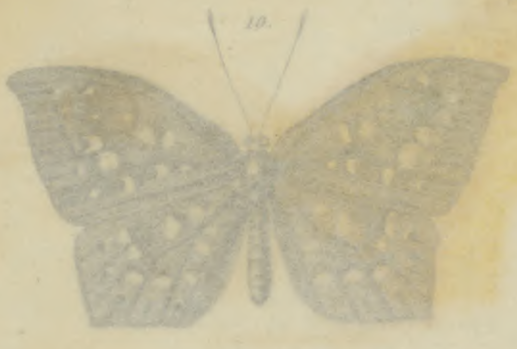
Larva of Morpho phidippus.

9.



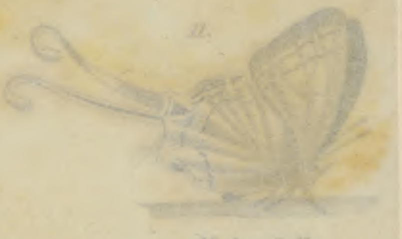
Urania Boisduvalii.

10.



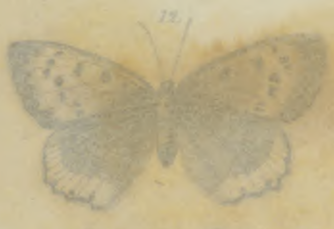
Eurybia carolina.

11.



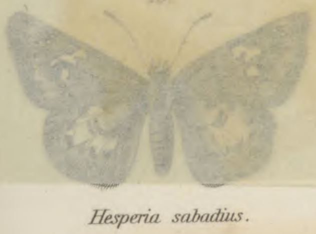
Myrina Jaffra.

12.



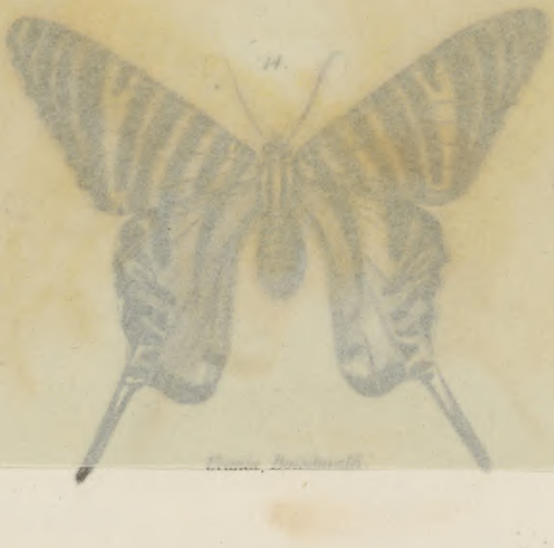
Polyommatus Ixos.

13.



Hesperia sabadius.

14.



Urania Boisduvalii

15.

Chrysalis and larva of
[illegible]

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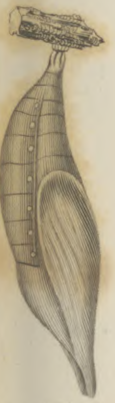
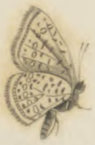
1.



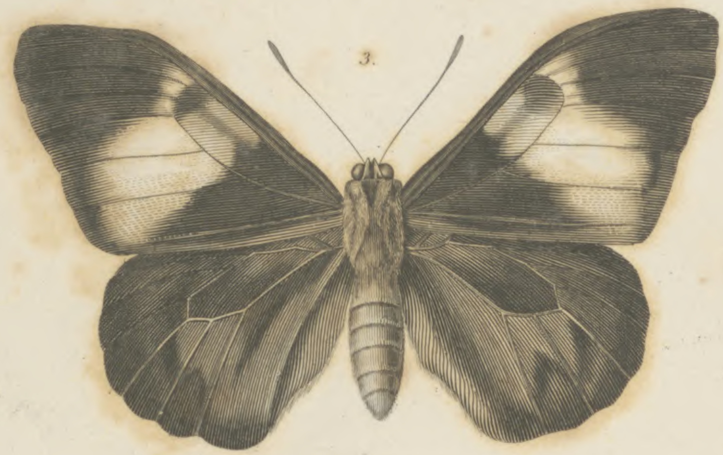
ysalis of Morpho phidippus.

2.



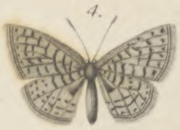
Erycina virginiensis.

3.



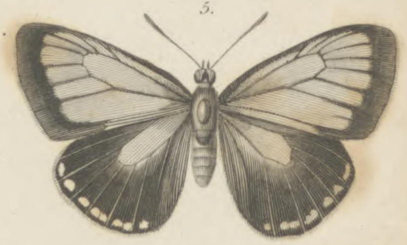
Brassolis astyra.

4.



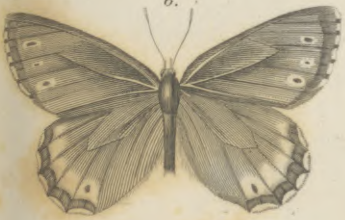
Erycina virginiensis.

5.



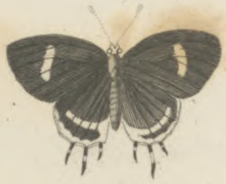
Eumenia toxea.

6.



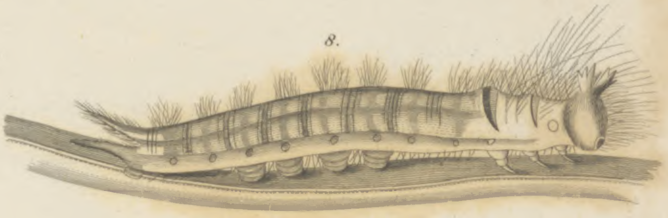
Satyrus Balder.

7.



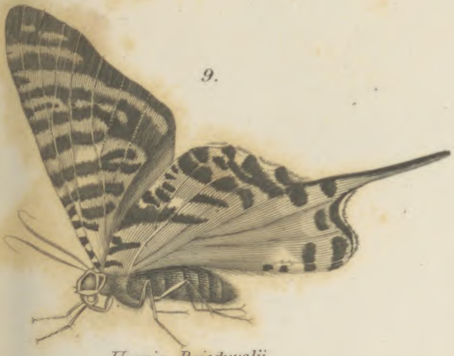
Zephyrius amor.

8.



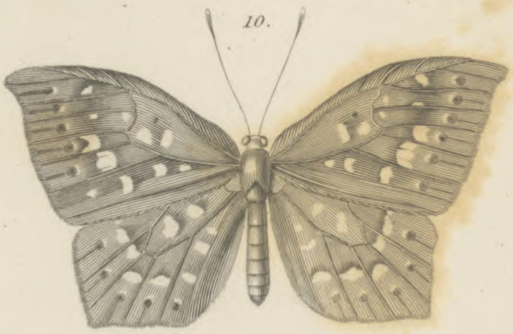
Larva of Morpho phidippus.

9.



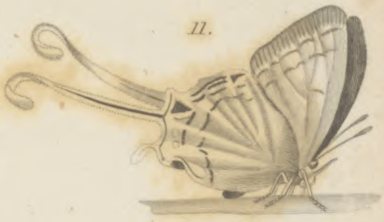
Urania Boisduvalii.

10.



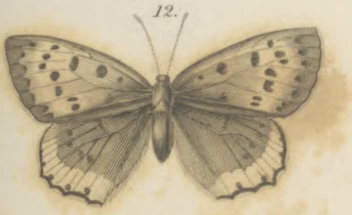
Eurybia carolina.

11.



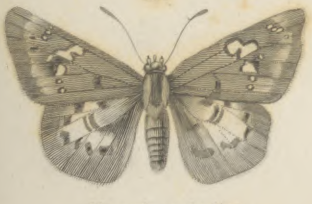
Myrina Jaffra.

12.



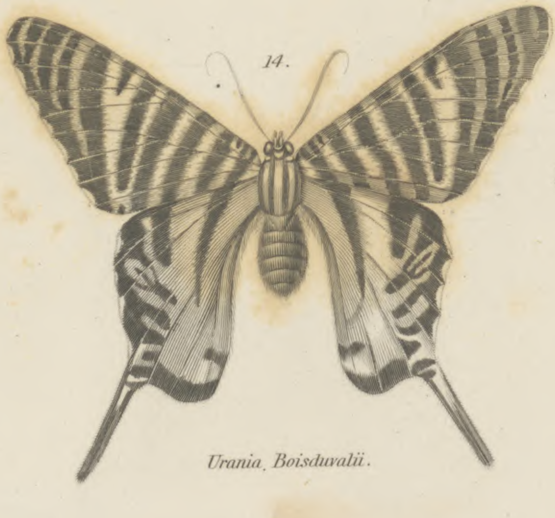
Polyommatus Thoe.

13.



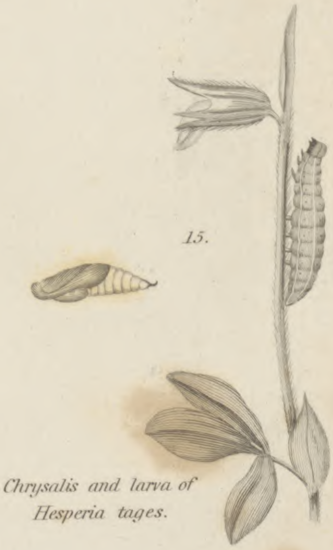
Hesperia sabadius.

14.



Urania Boisduvalii.

15.



Chrysalis and larva of Hesperia tages.

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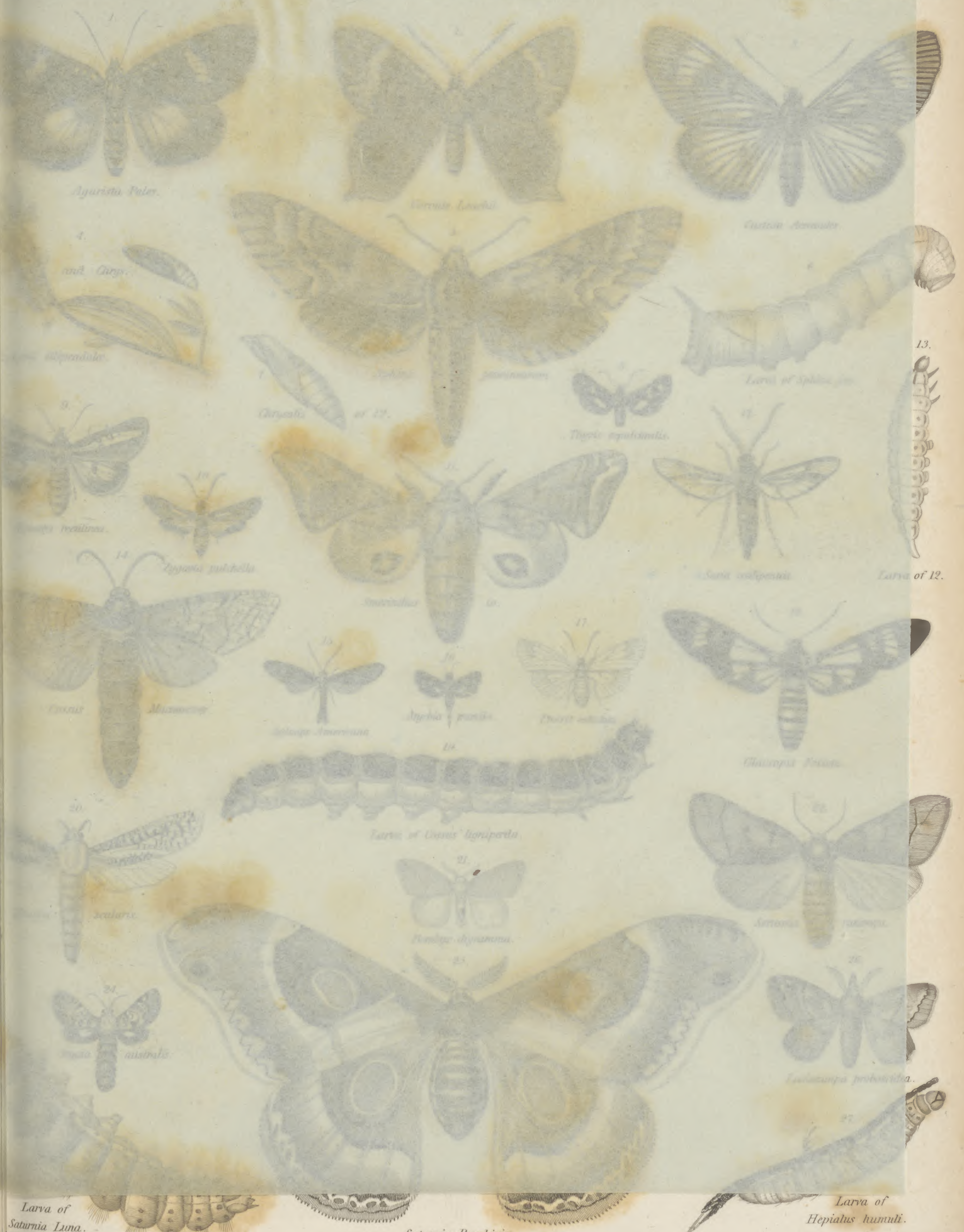
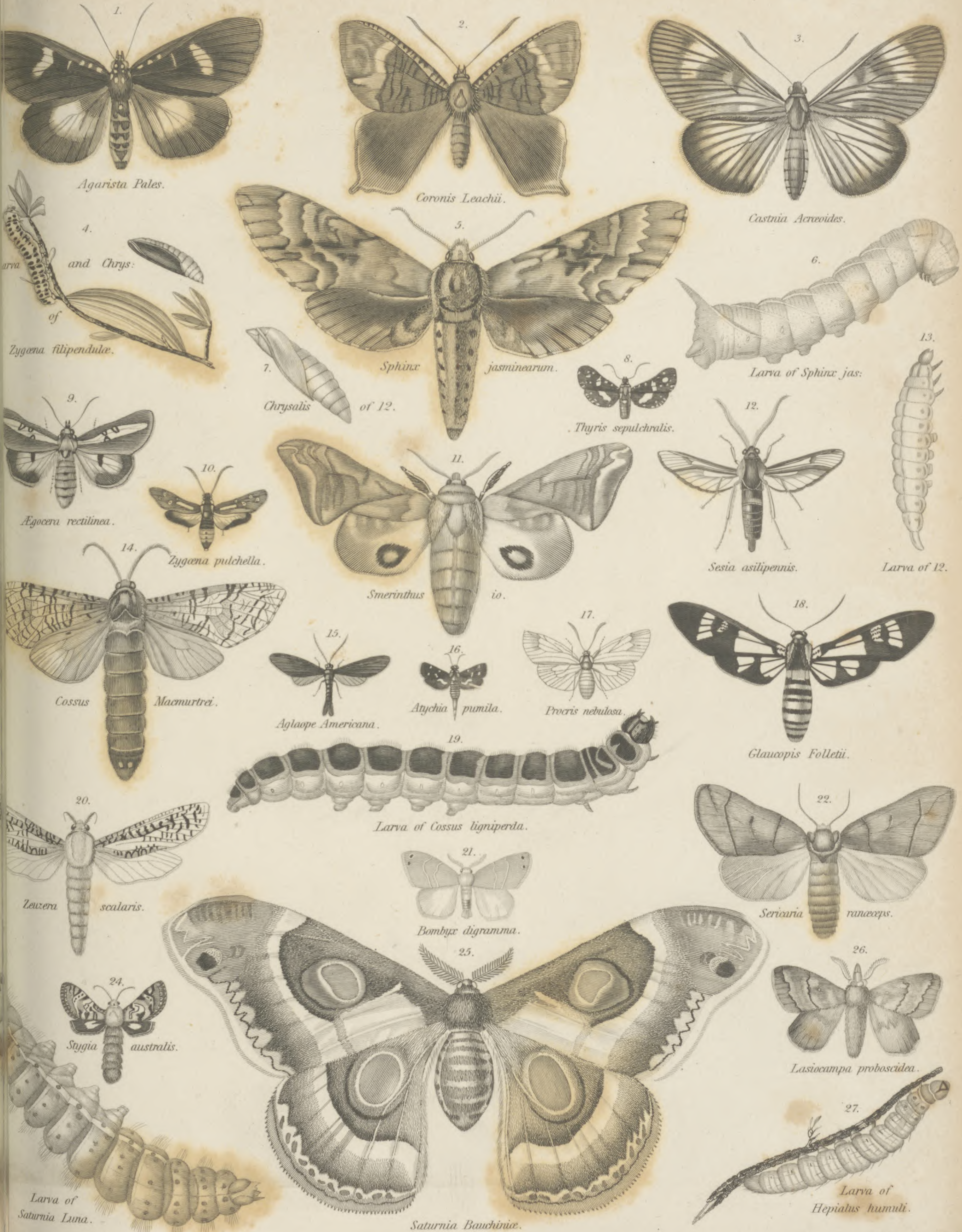
TERA. ENTOMOLOGY. PLATE CCXXXVI.



Eng.d by G. Aikman, Edin.r



1. Agarista Pales.

2. Coronis Leachii.

3. Castnia Acrœoides.

4. arva and Chrys: of Zygæna filipendulæ.

5. Sphinx jasminearum.

6. Larva of Sphinx jas:

7. Chrysalis of 12.

8. Thyris sepulchralis.

9. Ægocera rectilinea.

10. Zygæna pulchella.

11. Smerinthus io.

12. Sesia asilipennis.

13. Larva of 12.

14. Cossus Macmurtrei.

15. Aglaope Americana.

16. Atychia pumila.

17. Procris nebulosa.

18. Glaucopis Folletii.

19. Larva of Cossus ligniperda.

20. Zeuzera scalaris.

21. Bombyx digramma.

22. Sericaria ranæceps.

24. Stygia australis.

25. Saturnia Bauchiniæ.

26. Lasiocampa proboscidea.

27. Larva of Hepialus humuli.

Larva of Saturnia Luna.

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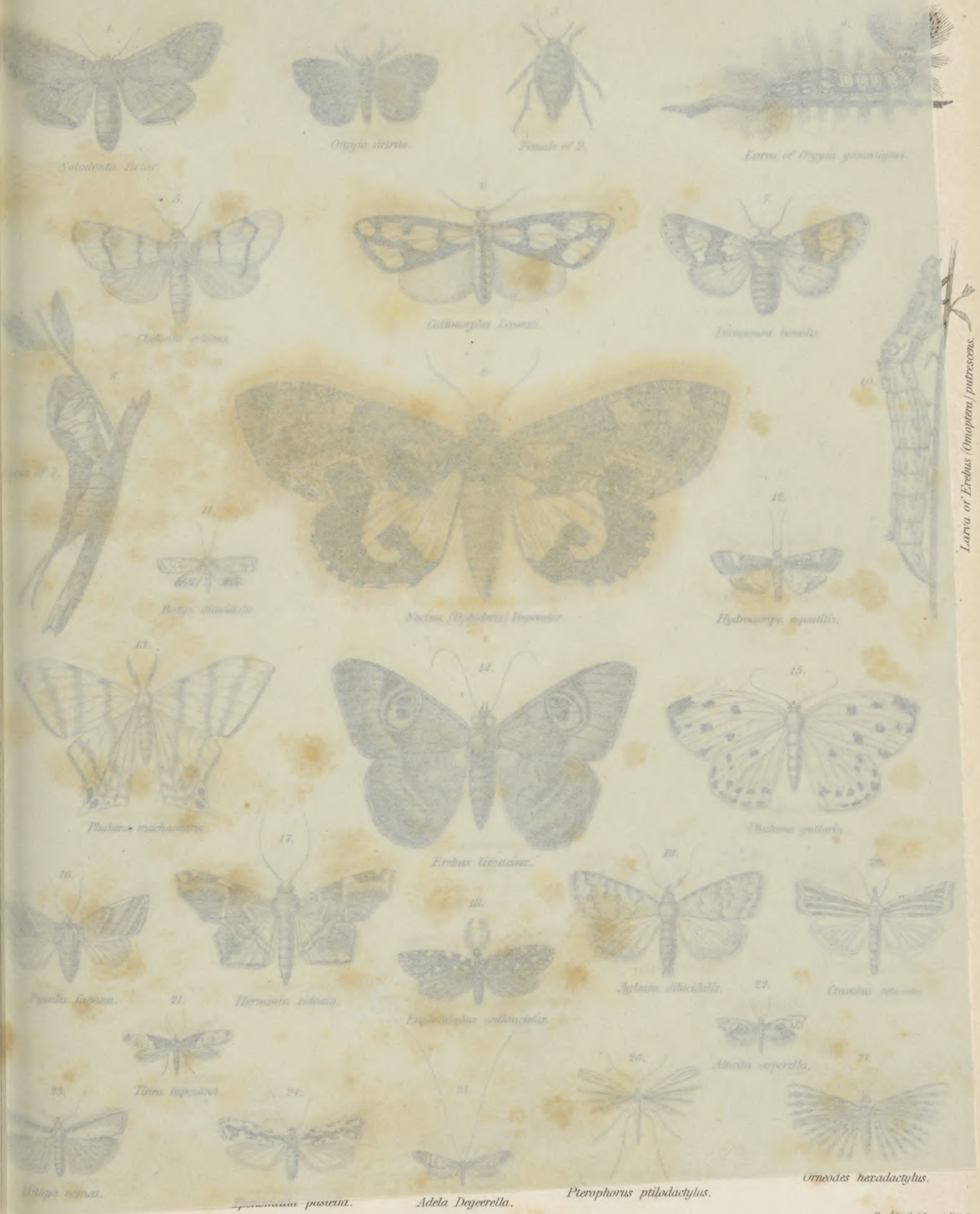
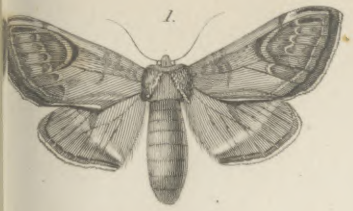


1. Notodonta Ziczac.
2. Orgyia detrita.
3. Female of 2.
4. Larva of Orgyia gonostigma.
5. Chelonia [illegible]
6. Callimorpha Lecontei.
7. Dicranura borealis.
8. va of 7.
9. Noctua (Ophideres) Imperator.
10. Larva of Erebus (Omoptera) putrescens.
11. Botys [illegible]
12. Hydrocampe aquatilis.
13. Phalaena machaonaria.
14. Erebus limacina.
15. Phalaena guttaria.
16. Pyralis [illegible]
17. Herminia [illegible]
18. Euplocamus anthracinalis.
19. Aglossa dilucidalis.
20. Crambus [illegible]
21. Tinea tapezana.
22. Alucita [illegible]
23. [illegible]
24. [illegible] pustella.
25. Adela Degeerella.
26. Pterophorus ptilodactylus.
27. Orneodes hexadactylus.

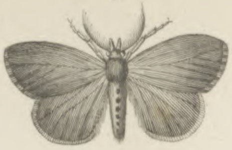
Eng.d by G. Aikman, Edin.r

1.



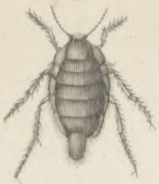
Notodonta ziczac.

2.



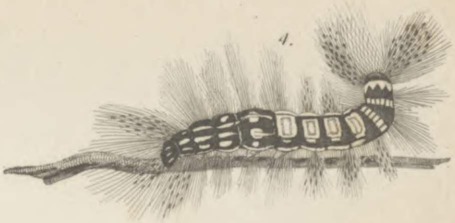
Orgyia detrita.

3.



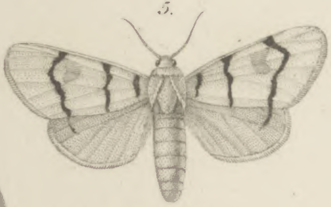
Female of 2.

4.



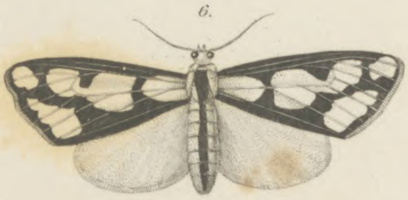
Larva of Orgyia gonostigma.

5.



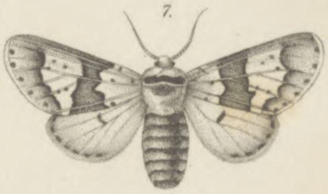
Chelonia evidens.

6.



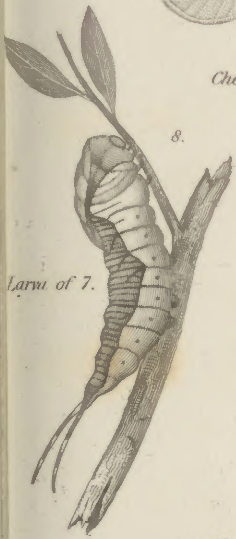
Callimorpha Lecontei.

7.



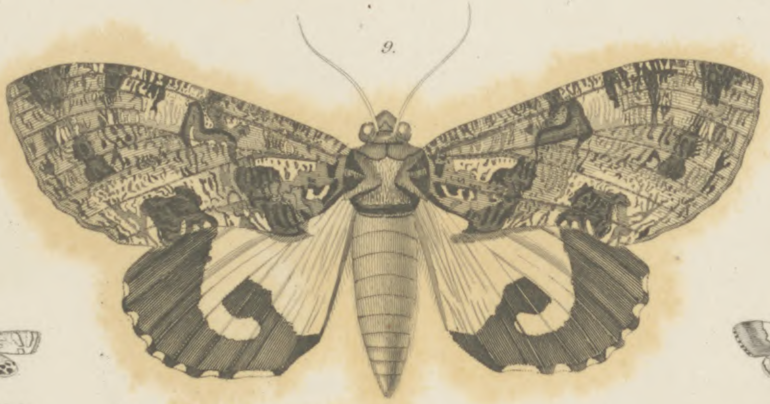
Dicranoura borealis.

8.



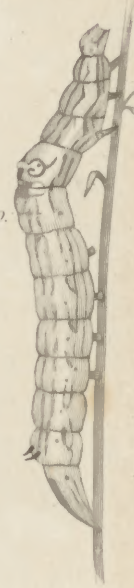
Larva of 7.

9.



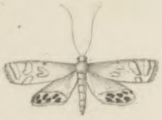
Noctua (Ophideres) Imperator.

10.



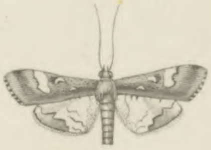
Larva of Erebus (Omoptera) putrescens.

11.



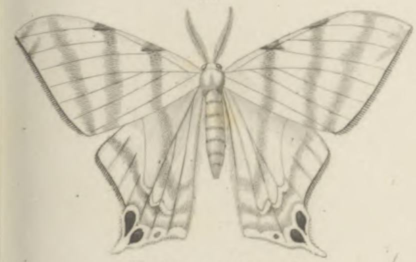
Botys dilucidalis.

12.



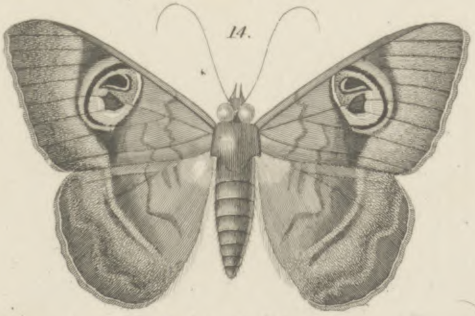
Hydrocampe aquatilis.

13.



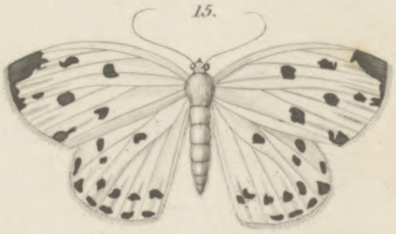
Phalæna machaonaria.

14.



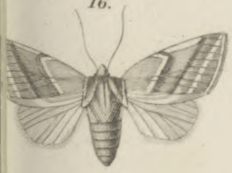
Erebus limacina.

15.



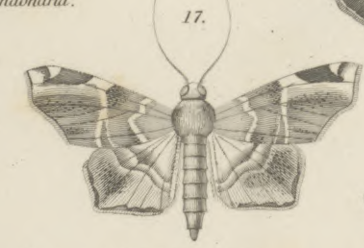
Phalæna guttaria.

16.



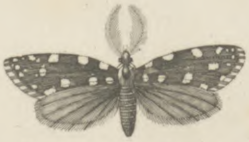
Pyralis fagana.

17.



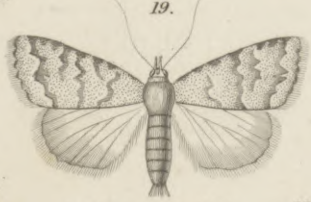
Herminia sidonia.

18.



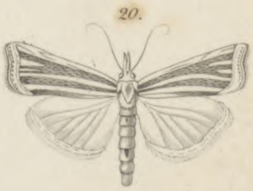
Euplocampus anthracinus.

19.



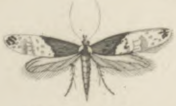
Aglossa dilucidalis.

20.



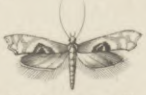
Crambus retusalis.

21.



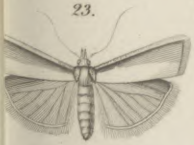
Tinea tapezana.

22.



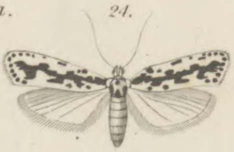
Alucita asperella.

23.



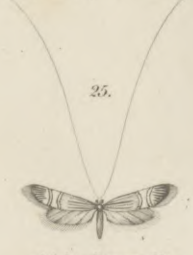
Ilithya carnea.

24.



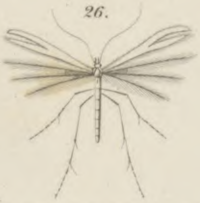
Yponomeuta pusiella.

25.



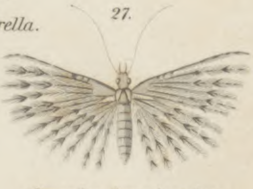
Adela Degeerella.

26.



Pterophorus ptilodactylus.

27.



Orneodes hexadactylus.

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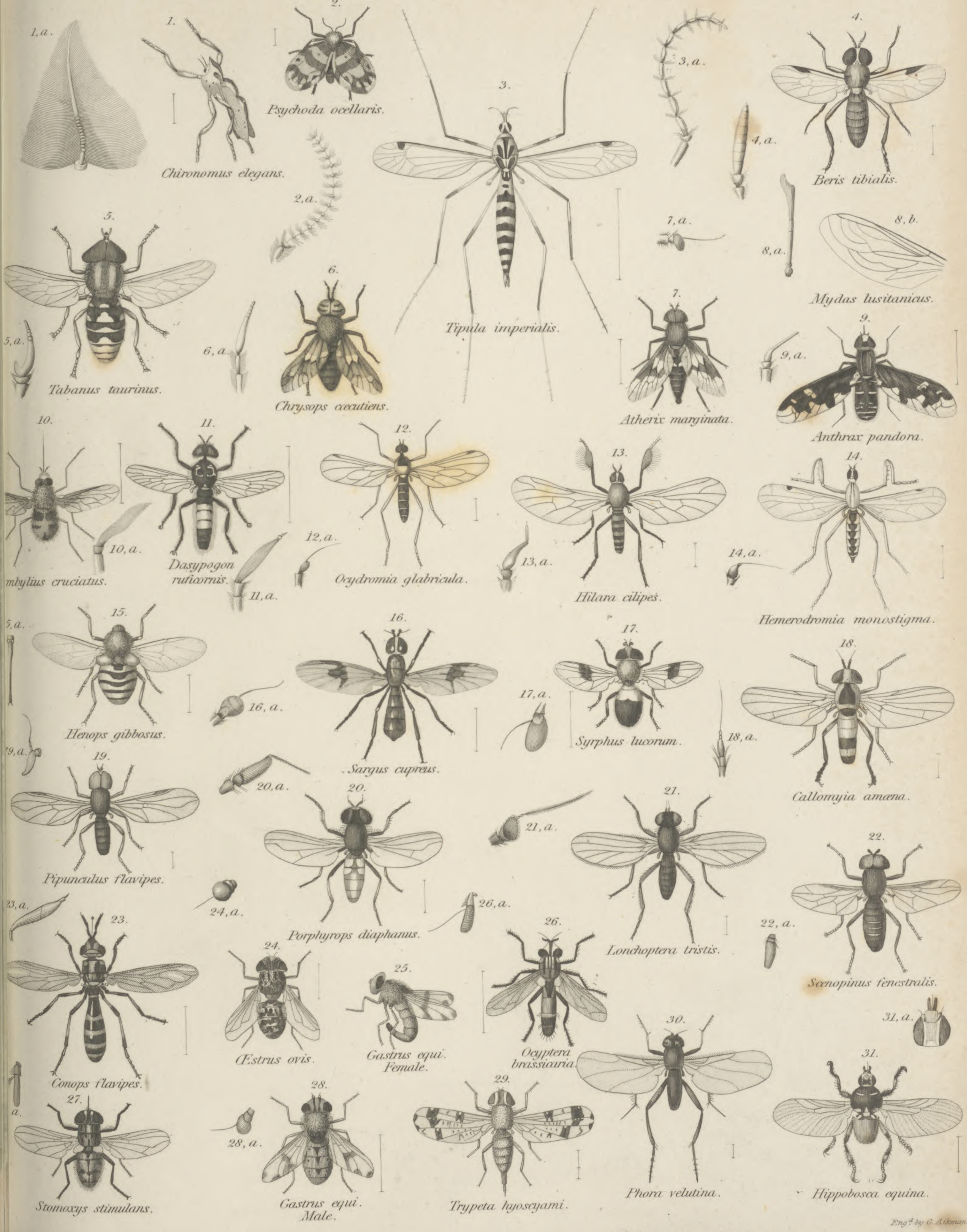
by G. Aikman Edi

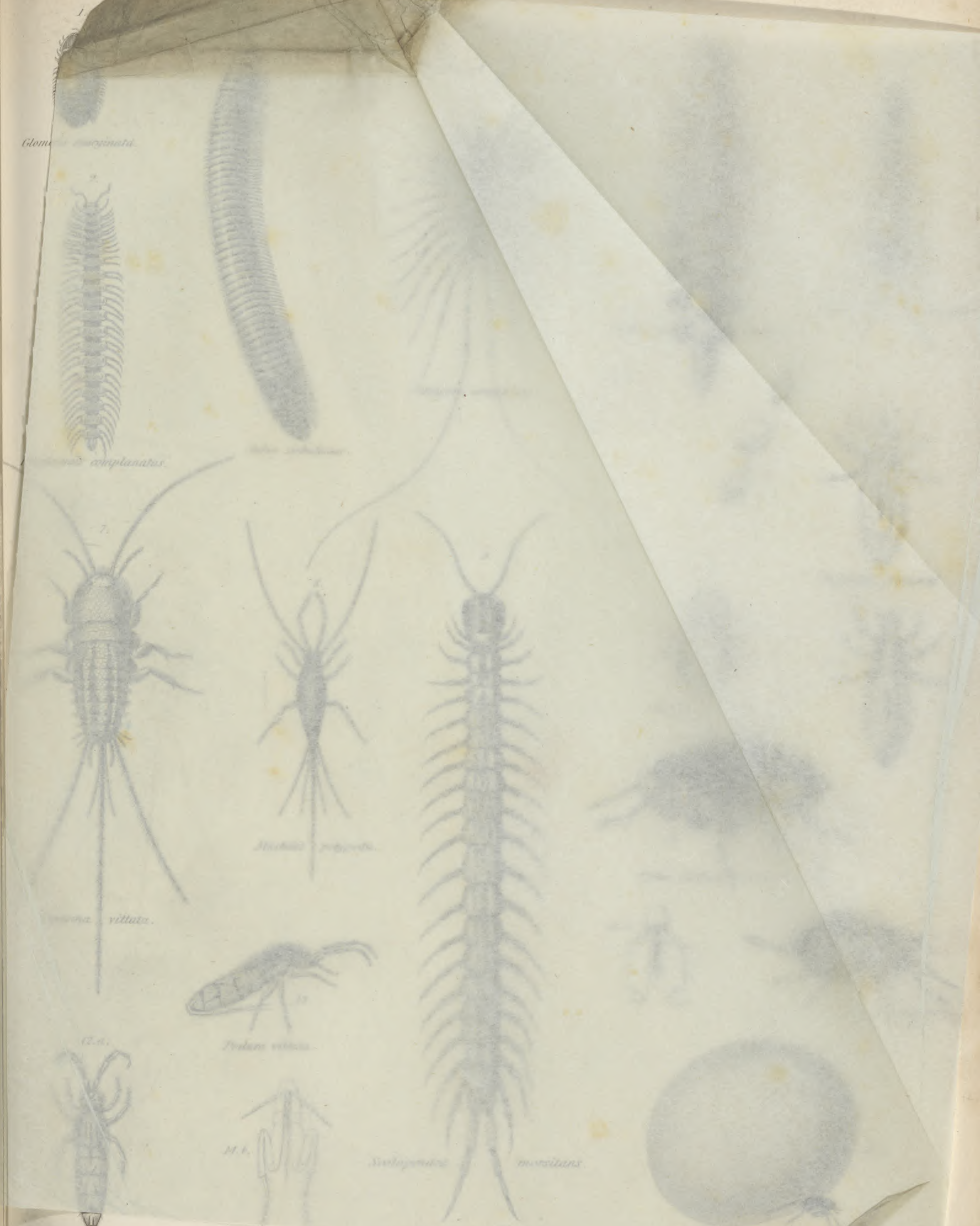
ENTOMOLOGY.

PLATE CCXXXVIII.


1,a.
1.
Chironomus elegans.
2.
Psychoda ocellaris.
2,a.
3.
Tipula imperialis.
3,a.
4.
4,a.
Beris tibialis.
7,a.
8,a.
8,b.
Mydas lusitanicus.
5.
5,a.
Tabanus taurinus.
6.
6,a.
Chrysops cæcutiens.
7.
Atherix marginata.
9.
9,a.
Anthrax pandora.
10.
10,a.
mbylius cruciatus.
11.
Dasypogon ruficornis.
11,a.
12.
12,a.
Ocydromia glabricula.
13.
13,a.
Hilara cilipes.
14.
14,a.
Hemerodromia monostigma.
5,a.
15.
Henops gibbosus.
16.
16,a.
Sargus cupreus.
17.
17,a.
Syrphus lucorum.
18.
18,a.
Callomyia amæna.
9,a.
19.
Pipunculus flavipes.
20,a.
20.
Porphyrops diaphanus.
21,a.
21.
Lonchoptera tristis.
22.
22,a.
Scenopinus fenestralis.
23,a.
23.
Conops flavipes.
24,a.
24.
Œstrus ovis.
25.
Gastrus equi. Female.
26,a.
26.
Ocyptera brassicaria.
30.
Phora velutina.
31,a.
31.
Hippobosca equina.
a.
27.
Stomoxys stimulans.
28.
28,a.
Gastrus equi. Male.
29.
Trypeta hyoscyami.

Engᵈ by G. Aikman E

ENTOMOLOGY AND MYRIAPODA.

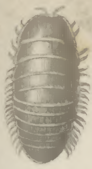


ENTOMOLOGY

SUCTORIA, Fig.s 13, 13 a, 14, 14 a & 14 b. | *THYSANOURA, Fig.s 7, 8, 12 & 12 a.* | *PARASITA, Fig.s 10, 11 & 11 a.*

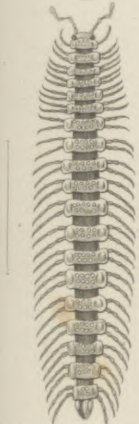
ENTOMOLOGY AND MYRIAPODA.

1.



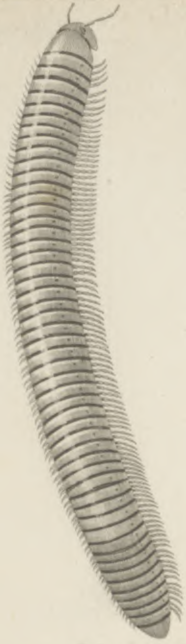
Glomeris marginata.

2.



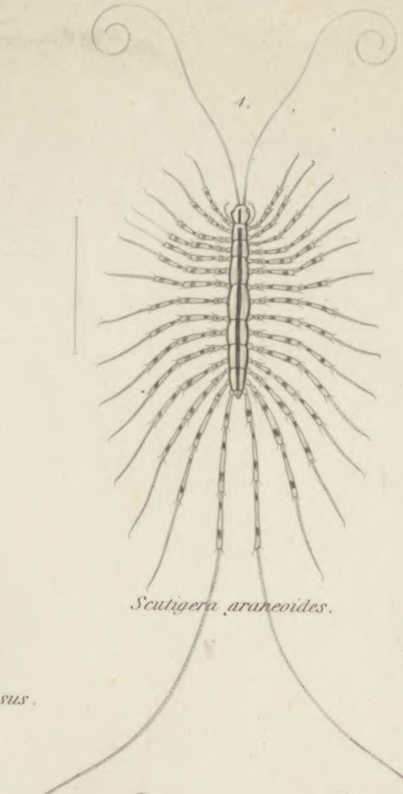
Polydesmus complanatas.

3.



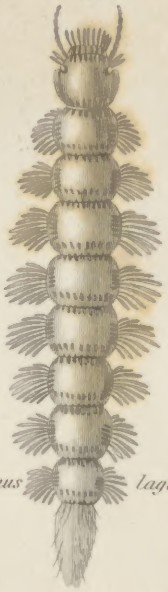
Julus sabulosus.

4.



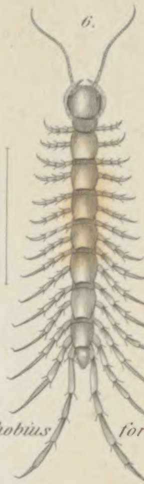
Scutigera araneoides.

5.



Polyxenus lagurus.

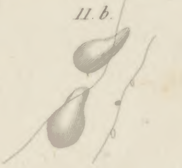
6.



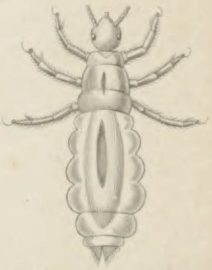
Lithobius forficatus.

10. a.

11. b.

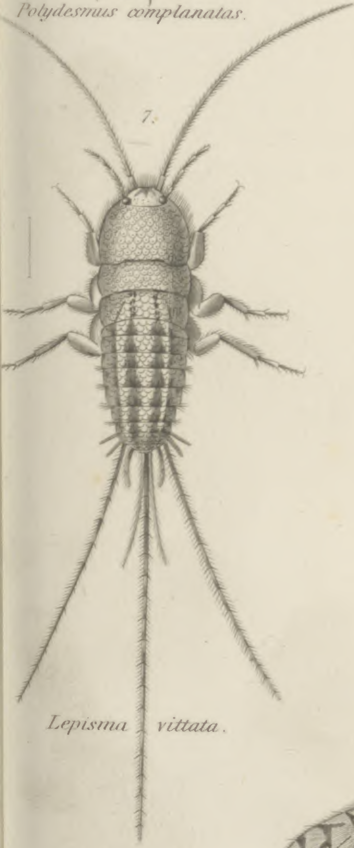


11.



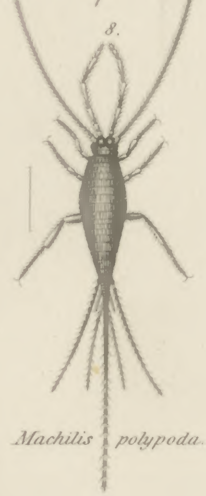
Pediculus humanus.

7.



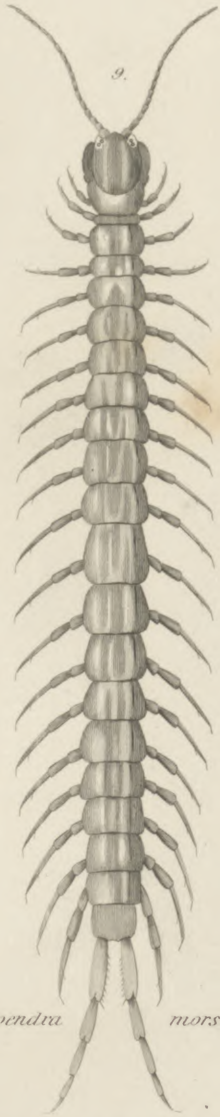
Lepisma vittata.

8.



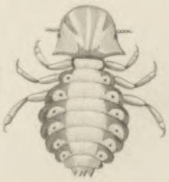
Machilis polypoda.

9.



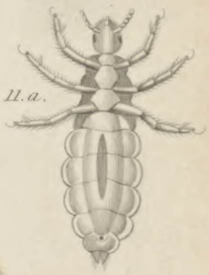
Scolopendra morsitans.

10.



Ricinus Pavonis.

11. a.



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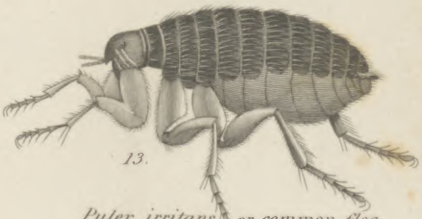
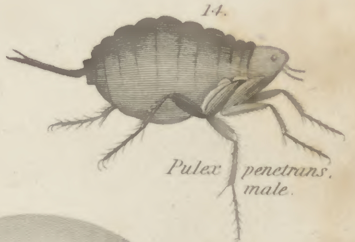


Pulex irritans, or common flea.

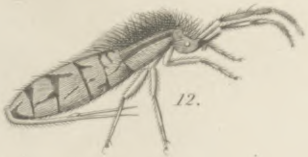
13. a.

14.



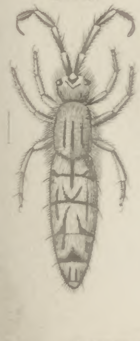
Pulex penetrans, male.

12.



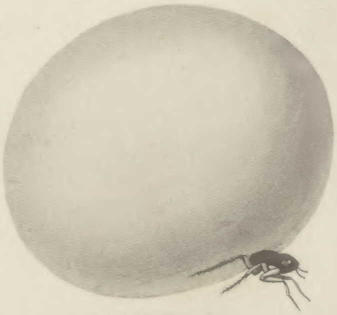
Podura villosa.

12. a.



14. b.

14. a.



gravid female.

ENTOMOLOGY.

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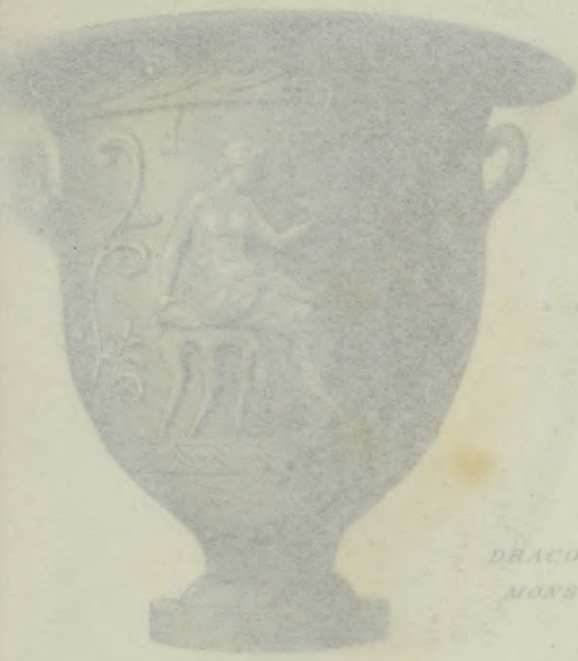
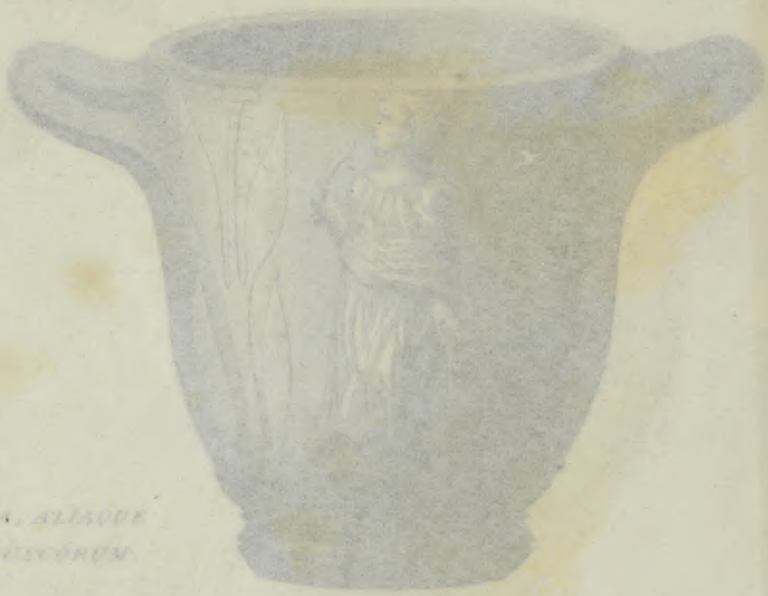
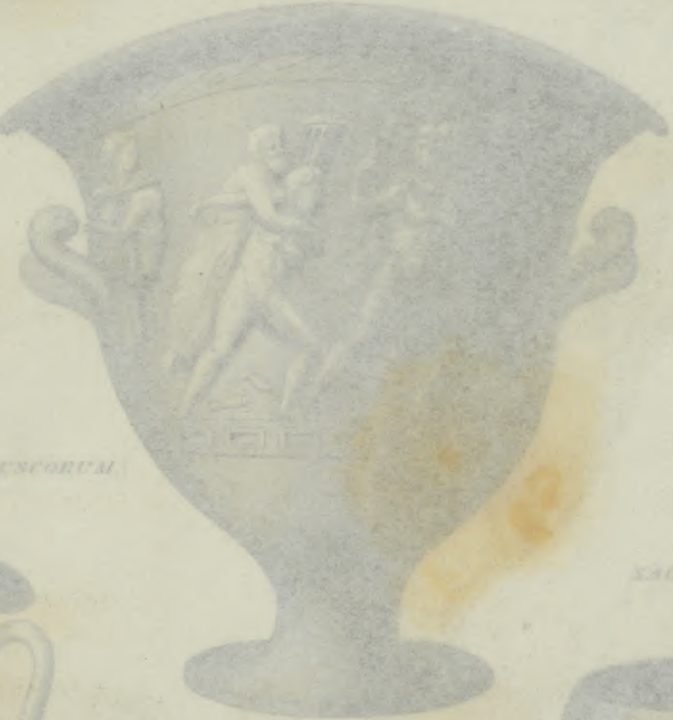
SUCTORIA, Figs 13, 13 a, 14, 14 a & 14 b. | THYSANOURA, Figs 7, 8, 12 & 12 a. | PARASITA, Figs 10, 11 & 11 a.



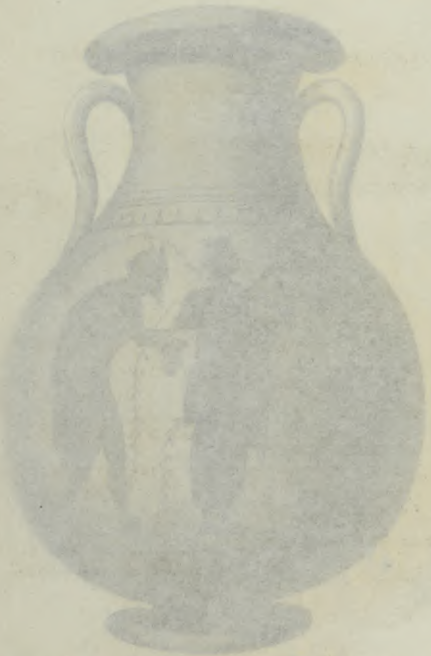
ULYSES APUD CIRCEN POTUS



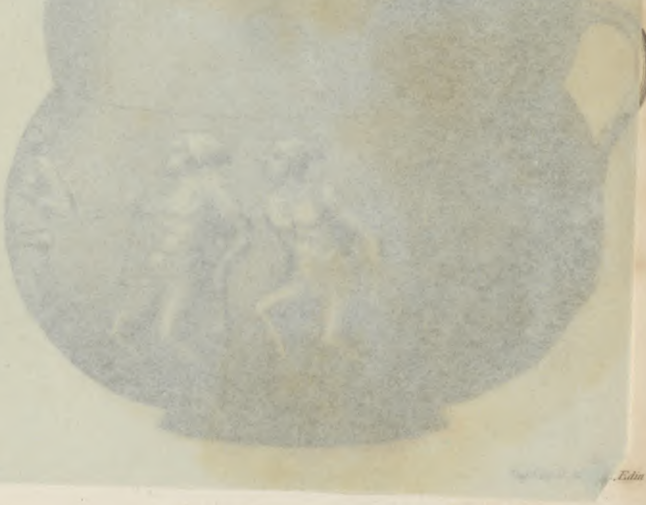
BELLONA ETRUSCORUM



DRACO, LEAENA, ALIAQUE MONSTRA ETRUSCORUM



MUSICA ET POËSIS ETRUSCORUM



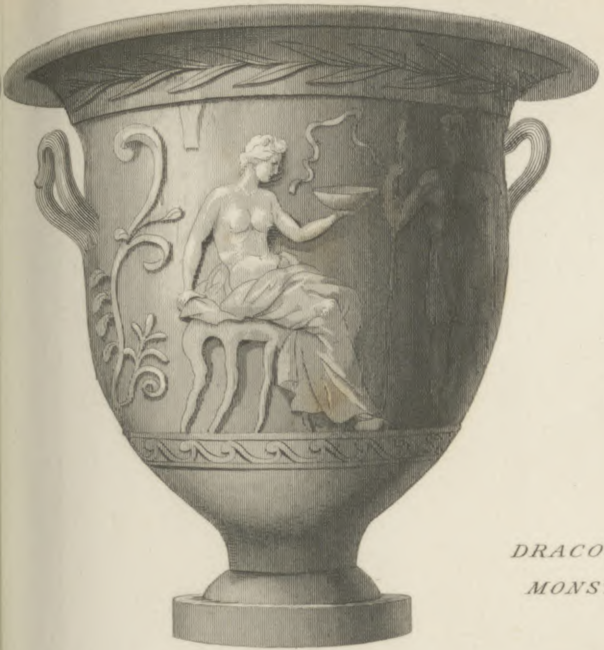
SACRA CEREALIA ET LENAEA.

[illegible] Edin^r

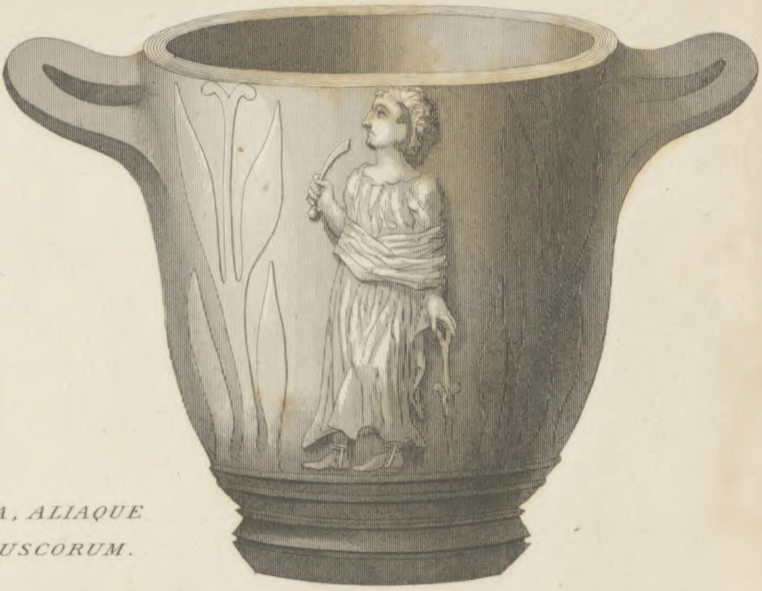
ETRUSCAN VASES.

PLATE CCXL.

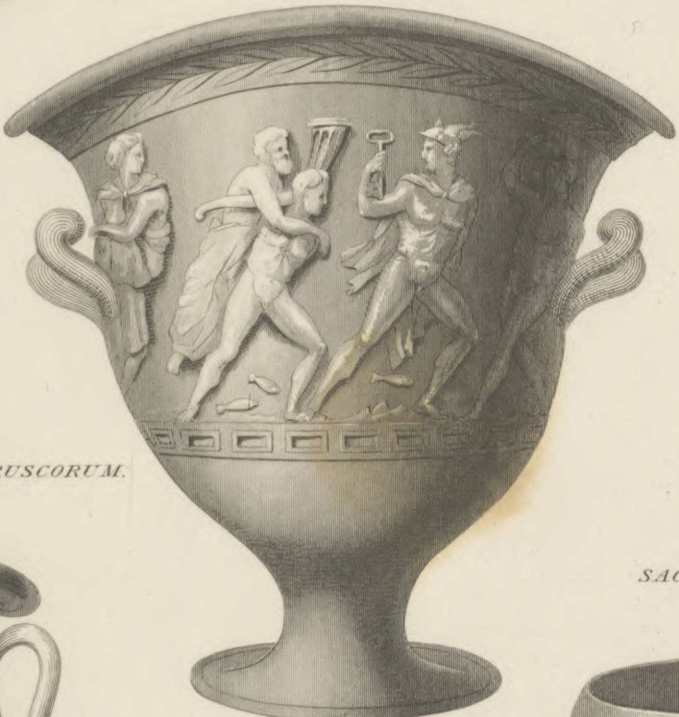
ULYSES APUD CIRCEN POTUS.



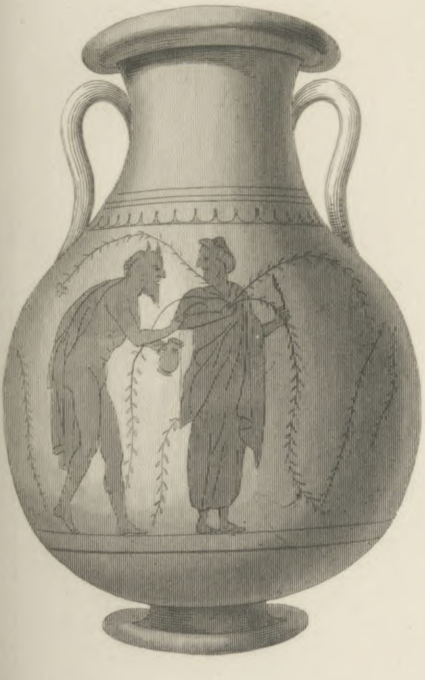
BELLONA ETRUSCORUM.



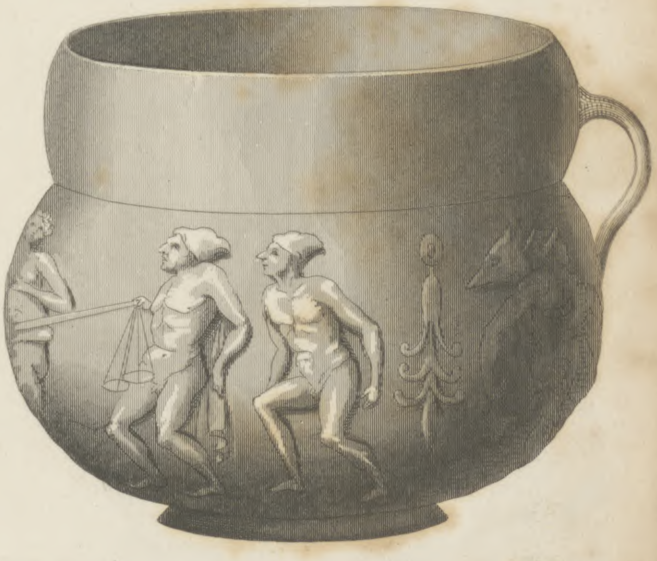
DRACO, LEAENA, ALIAQUE
MONSTRA ETRUSCORUM.



MUSICA ET POËSIS ETRUSCORUM.



SACRA CEREALIA ET LENAEA.



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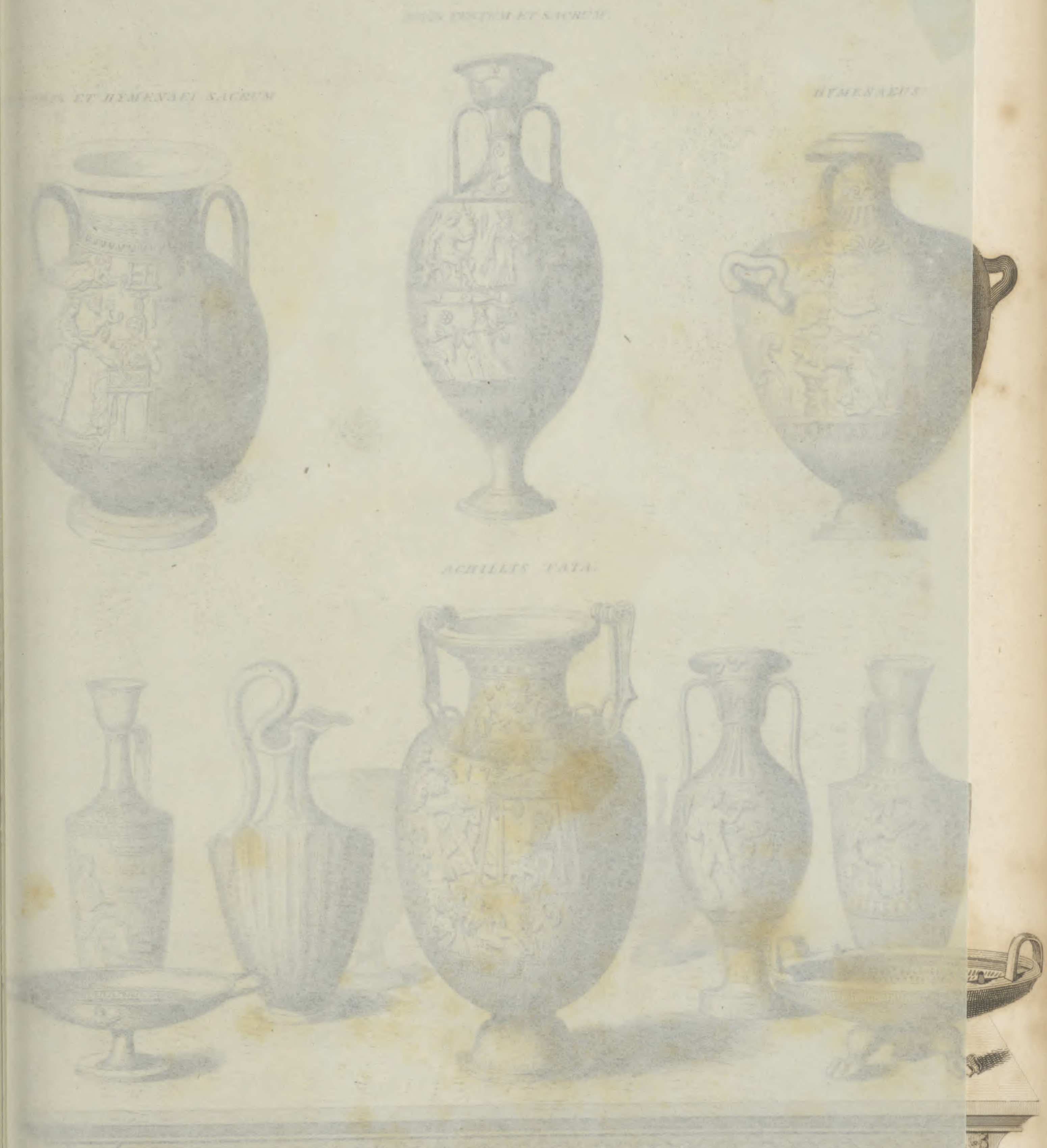
ETRUSCAN VASES.

PLATE CCXLI.



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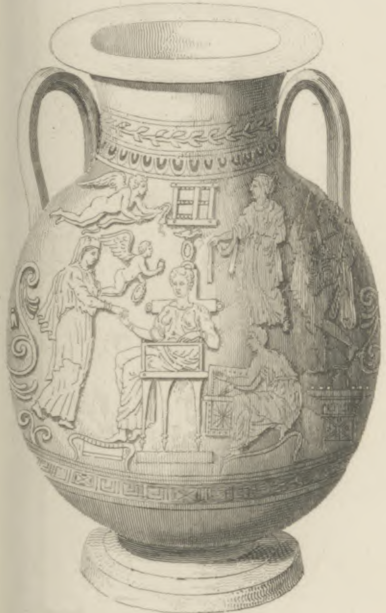
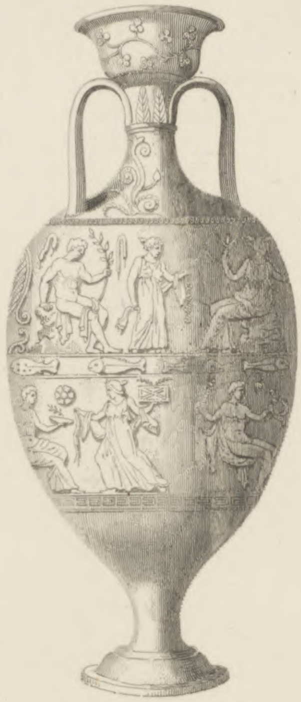
ETRUSCAN VASES.

PLATE CCXLI.

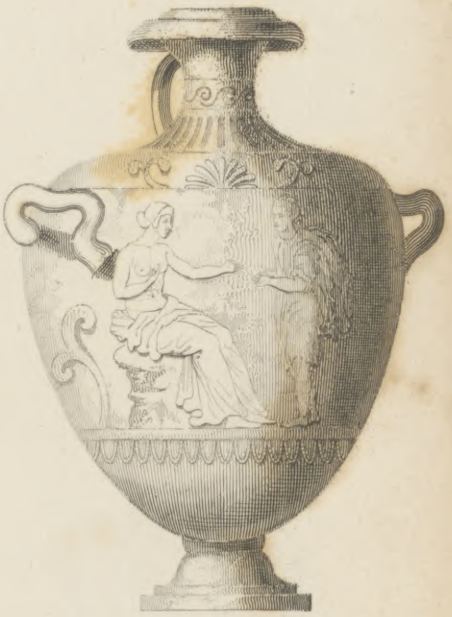
VENERIS ET HYMENAEI SACRUM.



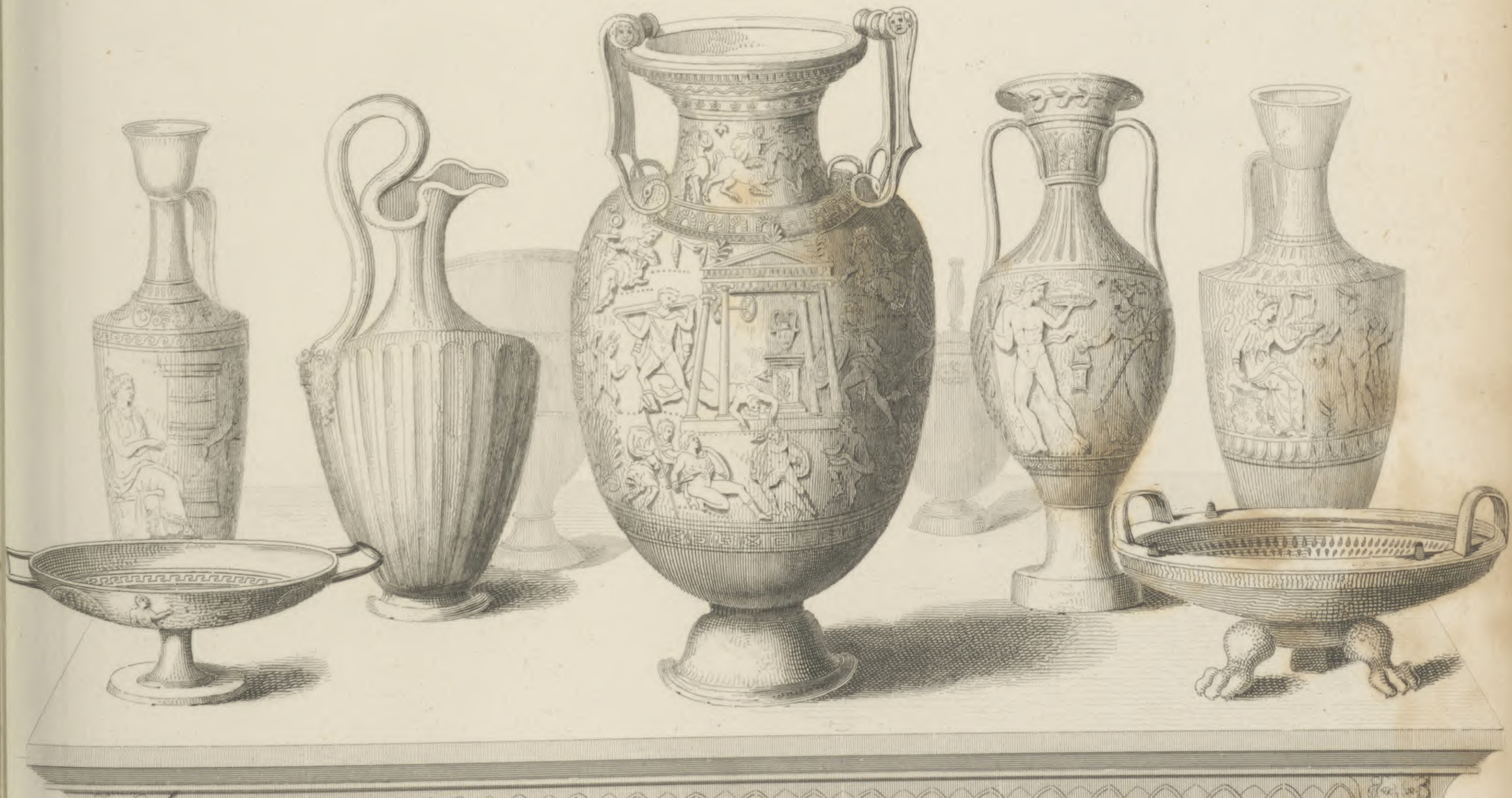
JOVIS FESTUM ET SACRUM.



HYMENAEUS.



ACHILLIS FATA.



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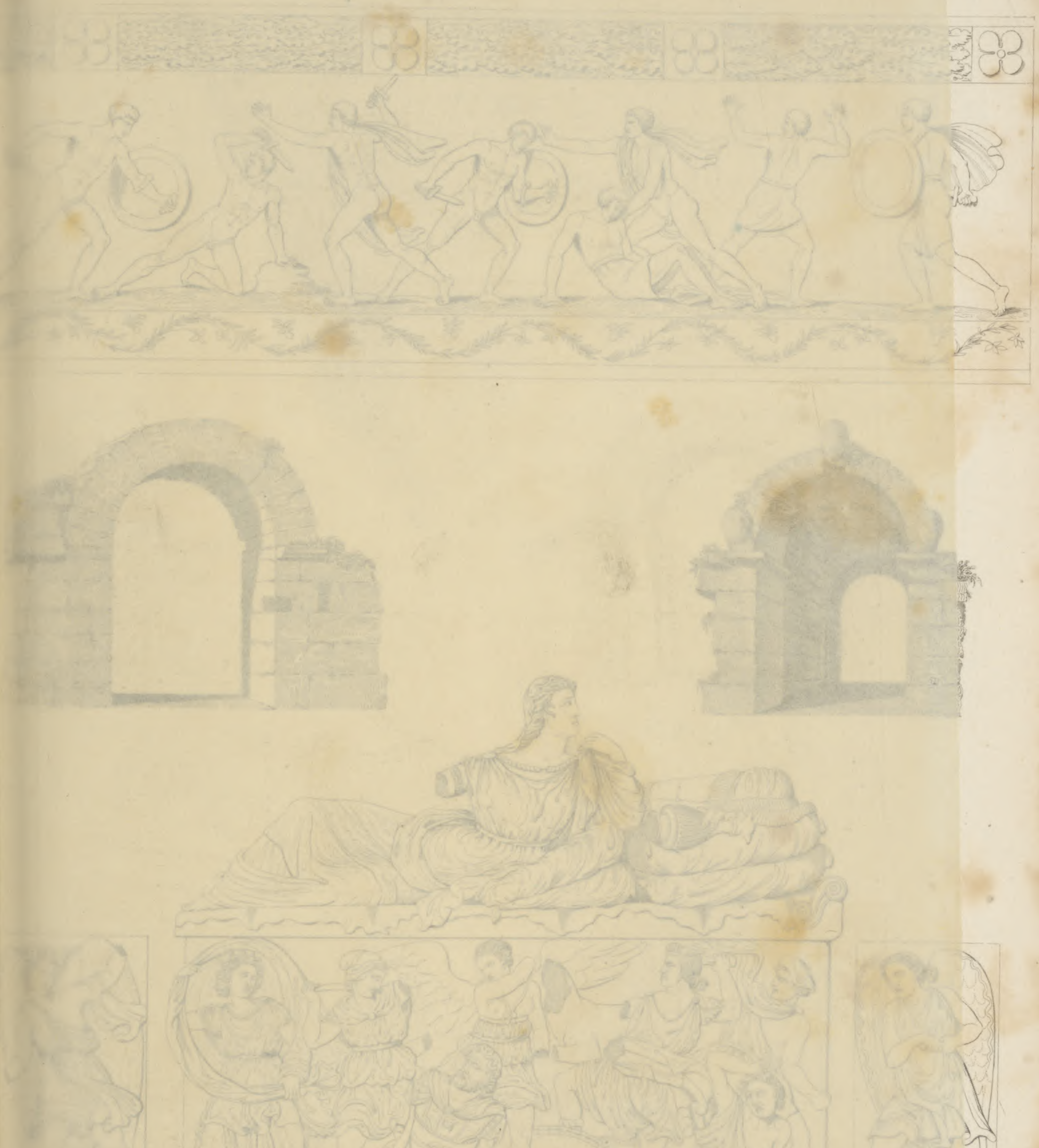
ETRUSCAN ANTIQUITIES. PLATE CCXLII.

(See Micali, Italia.)



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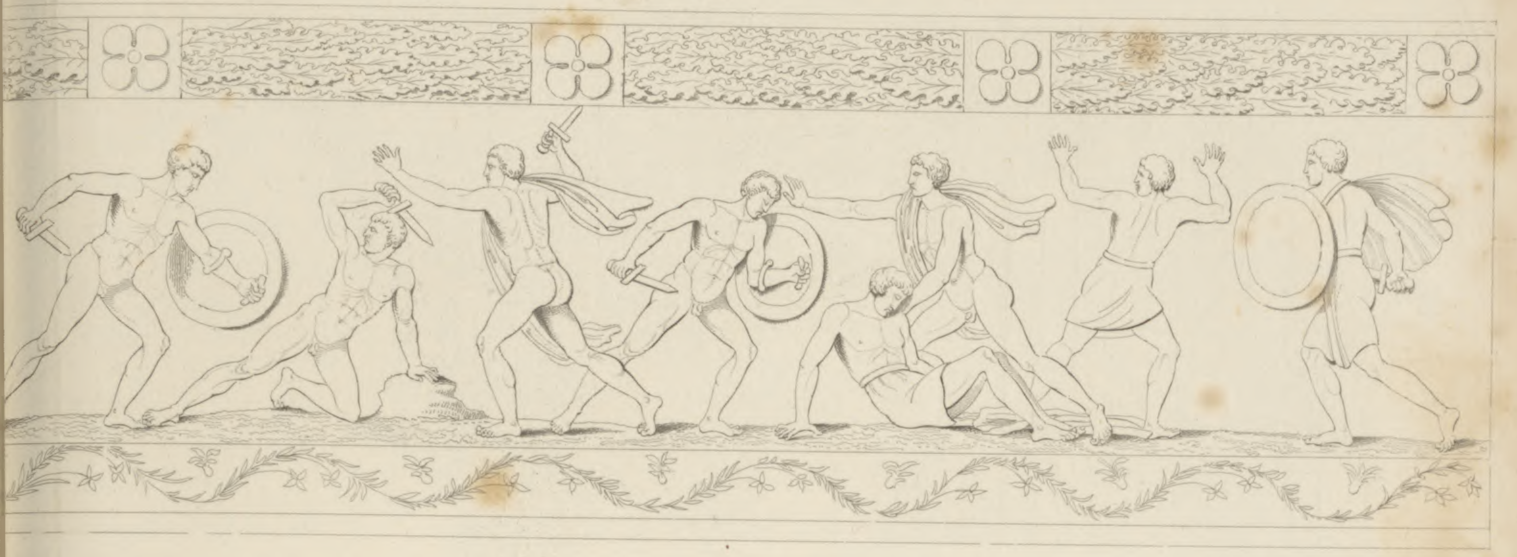
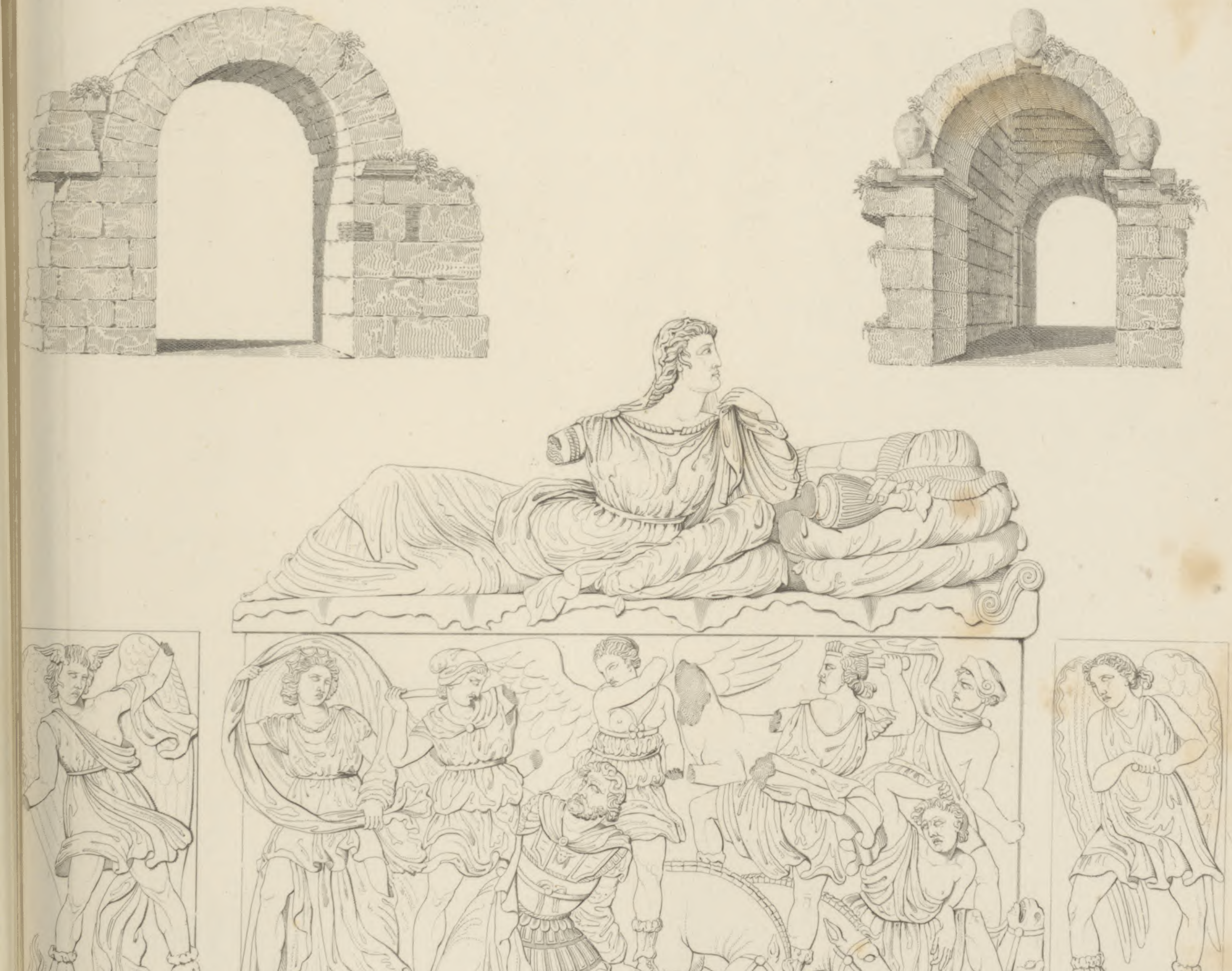
ETRUSCAN ANTIQUITIES.

PLATE CCXLII.

(See Micali, Italia.)





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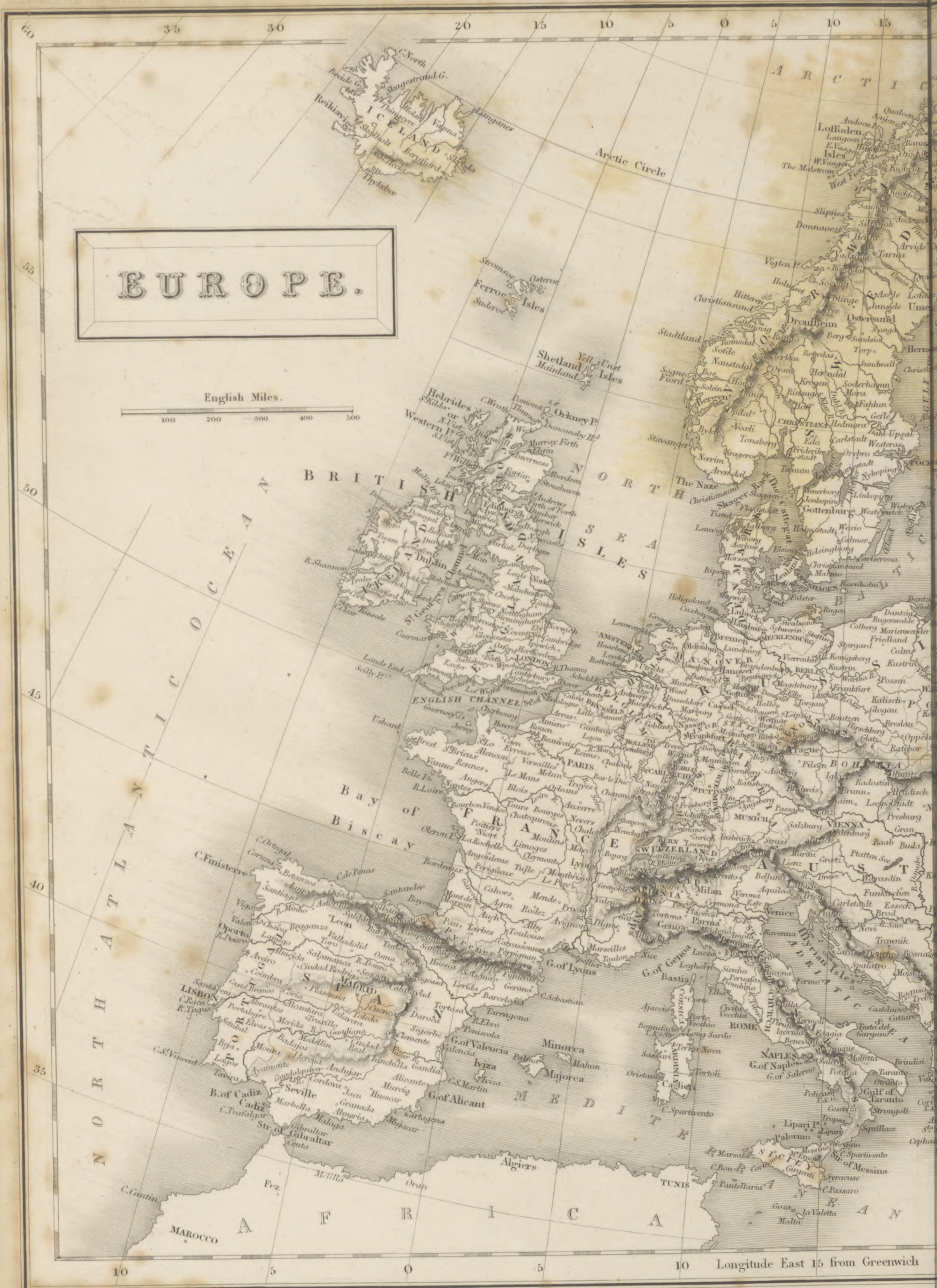
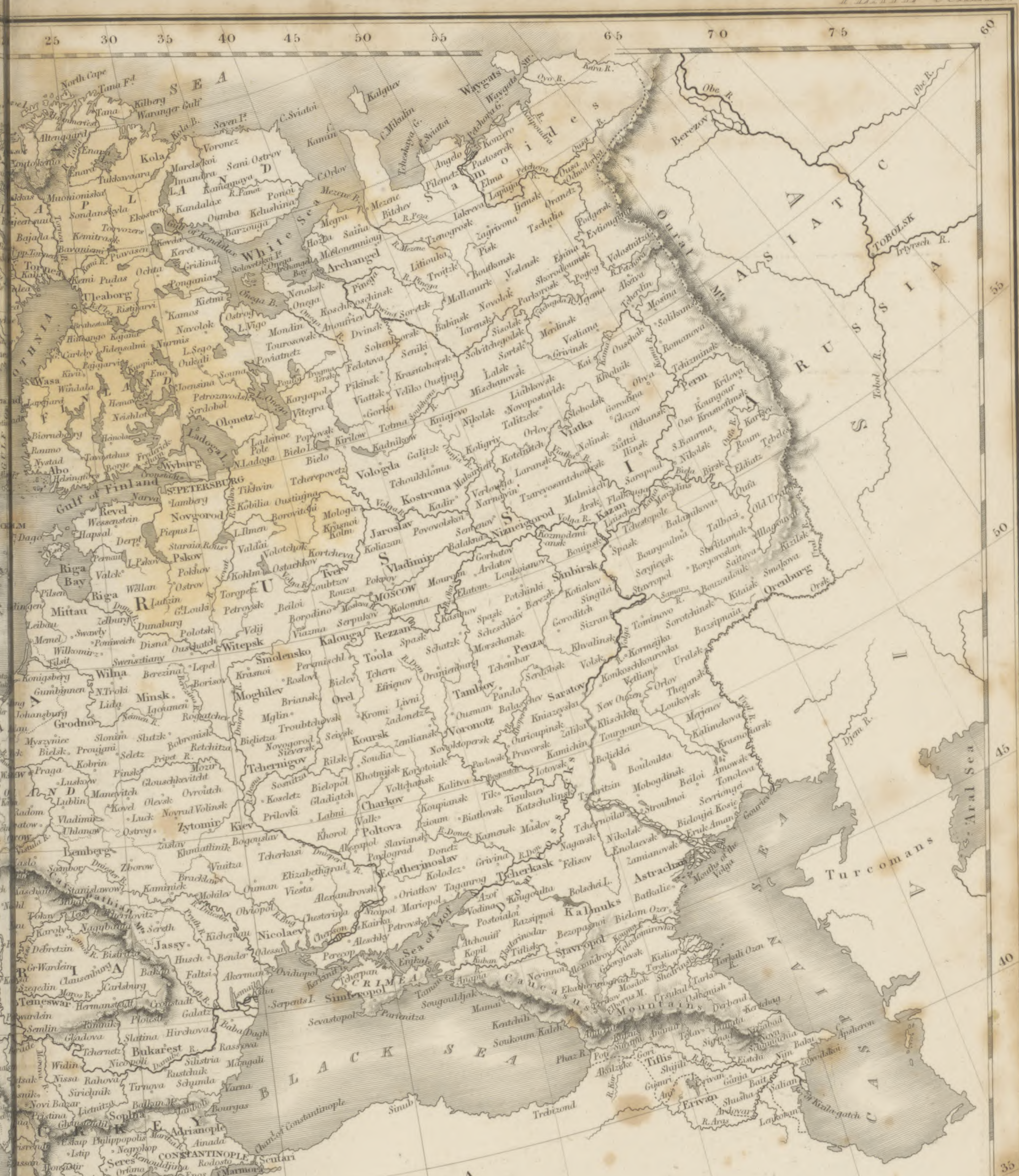

EUROPE.
English Miles.
100 200 300 400 500
ARCTIC
Arctic Circle
ICELAND
Reikiavik
Langanes
C. North
Ferroe Isles
Shetland Isles
Orkney Is.
Hebrides or Western Is.
BRITISH ISLES
NORTH SEA
NORTH ATLANTIC OCEAN
Dublin
LONDON
Edinburgh
ENGLISH CHANNEL
St. Georges Channel
Lands End
Scilly Is.
Ushant
Bay of Biscay
FRANCE
PARIS
Bordeaux
Lyons
Marseilles
G. of Lyons
SPAIN
MADRID
LISBON
PORTUGAL
C. Finisterre
C. Ortegal
C. St. Vincent
Seville
Cadiz
C. Trafalgar
Str. of Gibraltar
Gibraltar
Ceuta
Malaga
Granada
G. of Alicant
Minorca
Majorca
Iviza
MEDITERRANEAN
AFRICA
Algiers
TUNIS
MAROCCO
Fez
C. Cantin
Oran
Melilla
SWITZERLAND
SARDINIA
Corsica
Ajaccio
Bastia
Cagliari
G. of Genoa
Genoa
Milan
Venice
ROME
NAPLES
G. of Naples
SICILY
Palermo
Messina
Str. of Messina
Syracuse
C. Passaro
Malta
la Valetta
Gozo
Pantellaria
G. of Taranto
Brindisi
Lipari Is.
ADRIATIC
Illyrian Isles
AUSTRIA
VIENNA
BOHEMIA
Prague
MUNICH
BAVARIA
HANOVER
Hamburg
Bremen
BERLIN
PRUSSIA
SAXONY
DRESDEN
Leipzig
AMSTERDAM
HOLLAND
BELGIUM
BRUSSELS
Heligoland
DENMARK
COPENHAGEN
Skager Rack
The Cattegat
The Naze
Christiansand
NORWAY
Bergen
CHRISTIANIA
Drontheim
Stavanger
Lofoden Isles
The Malstrom
West Fiord
SWEDEN
STOCKHOLM
Gottenburg
Upsal
BALTIC
Dantzig
Konigsberg
Longitude East 15 from Greenwich
Longitude West 35 30 20 15 10 5 0 5 10 15
Latitude 60 55 50 45 40 35
10 5 0 5 10



Engraved by S. Hall Bury Stʳ. Bloomsbʸ.

FIGURE OF THE EARTH.

PLATE CCXLIV.

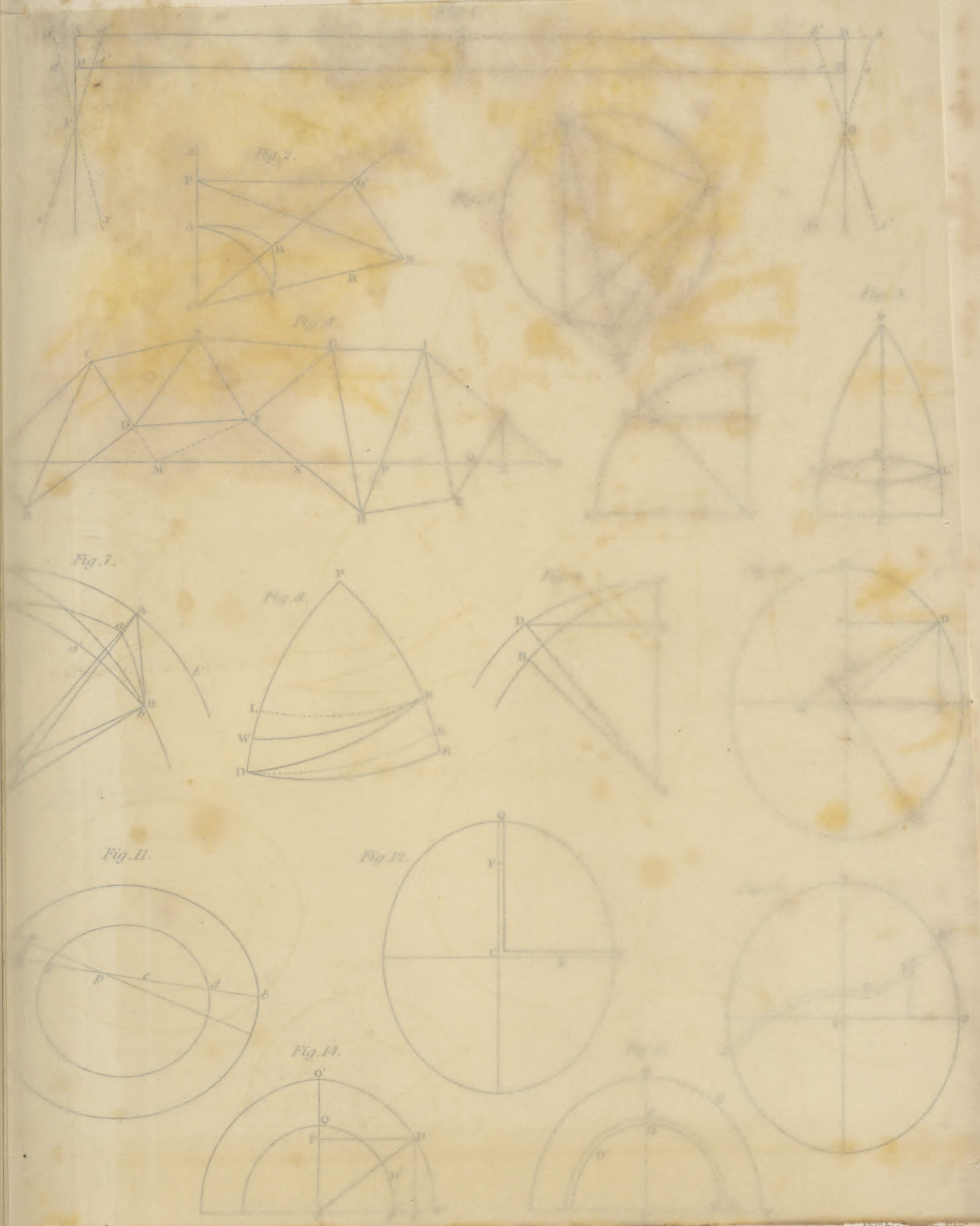


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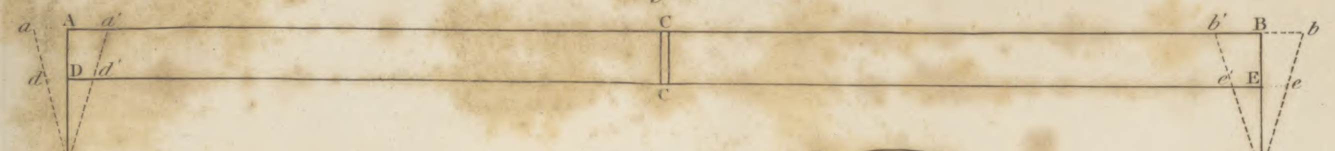
FIGURE OF THE EARTH.

PLATE CCXLIV.

Fig. 1.



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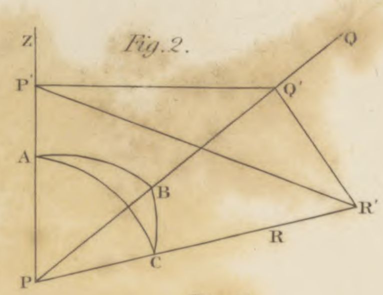


Fig. 3.

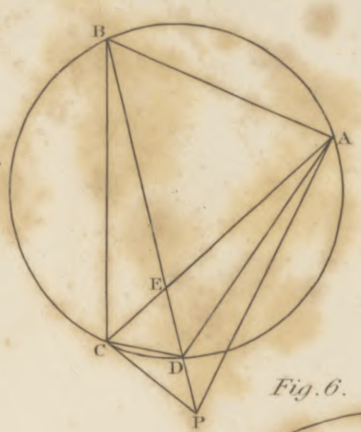


Fig. 4.

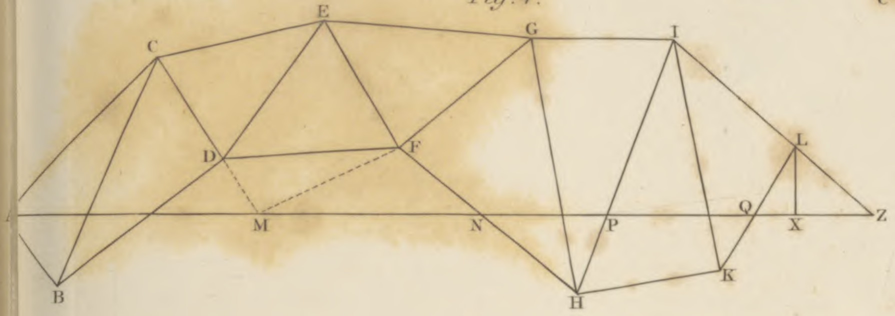
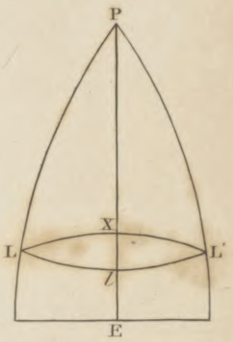


Fig. 5.



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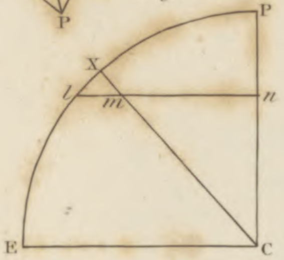


Fig. 7.

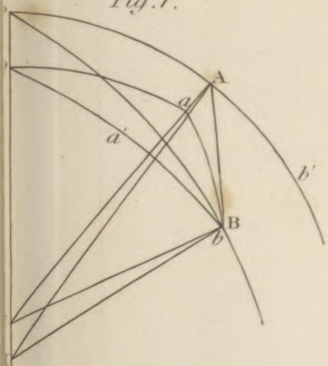


Fig. 8.

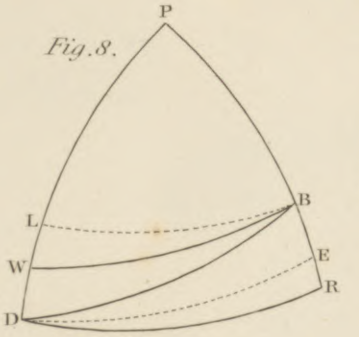


Fig. 9.

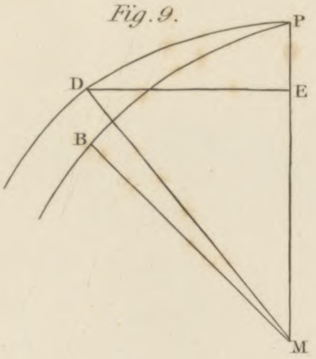


Fig. 10.

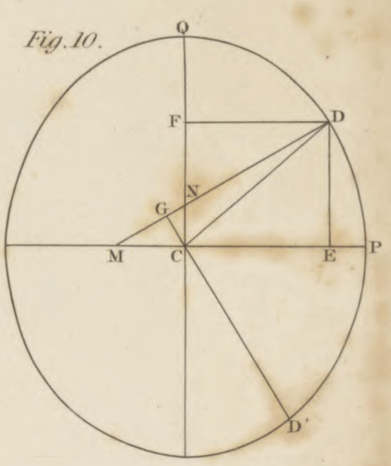
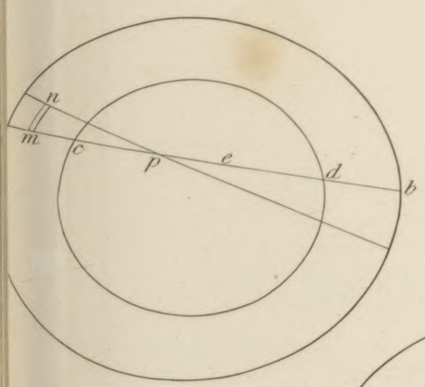


Fig. 11.



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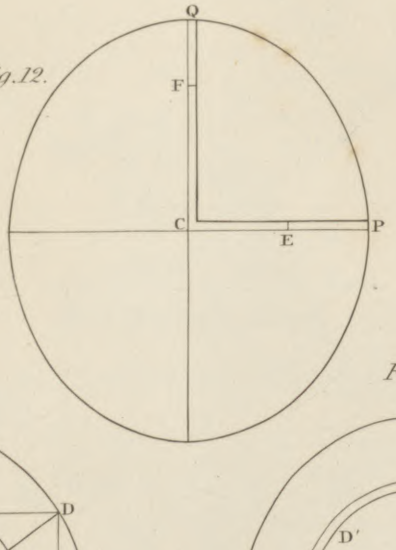

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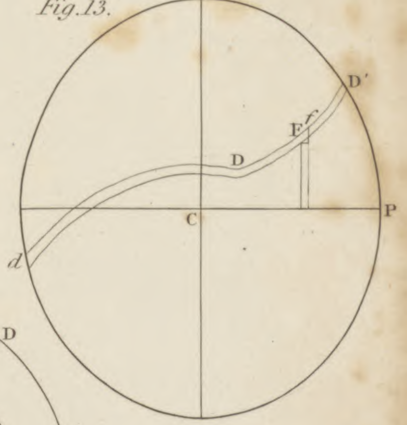

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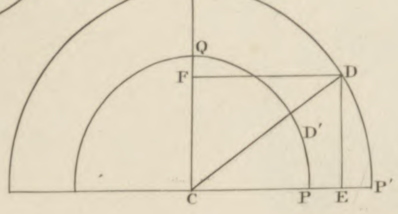

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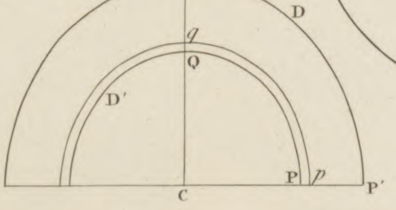

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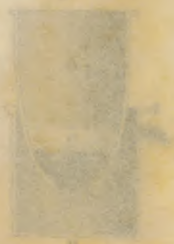
Fig. 7.

Fig. 2.



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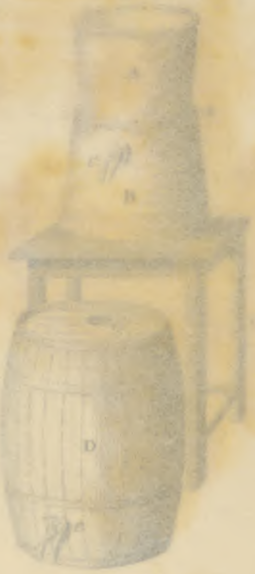

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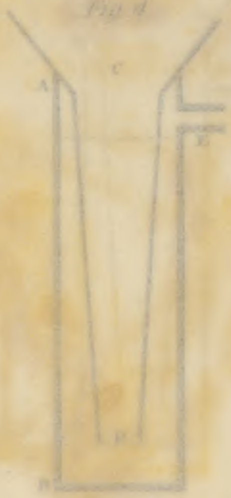

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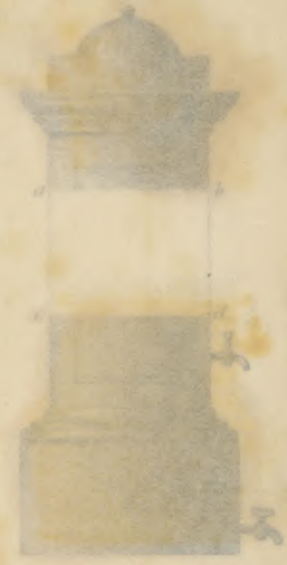

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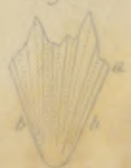

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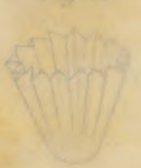

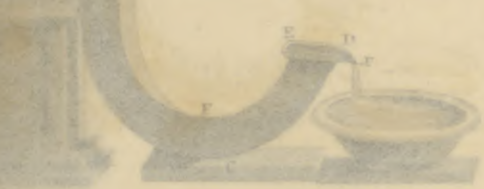

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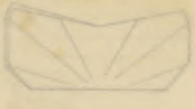

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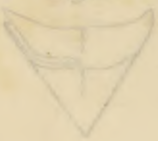

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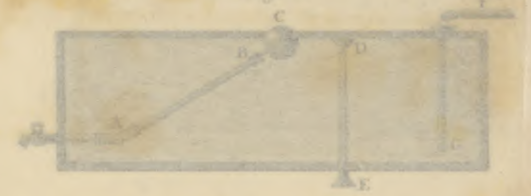

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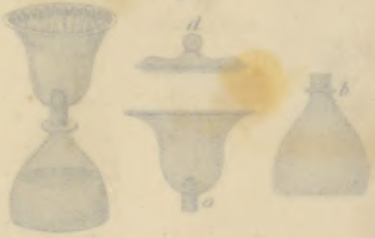

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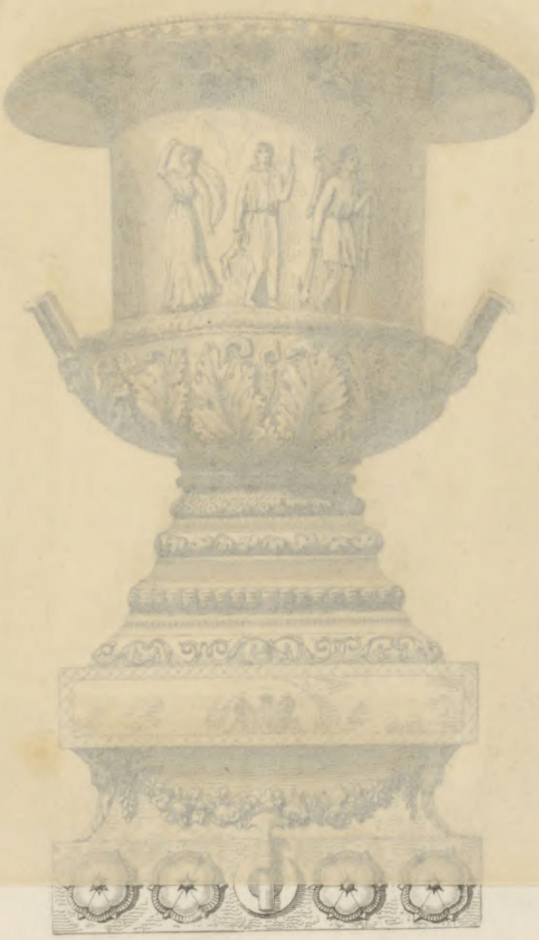

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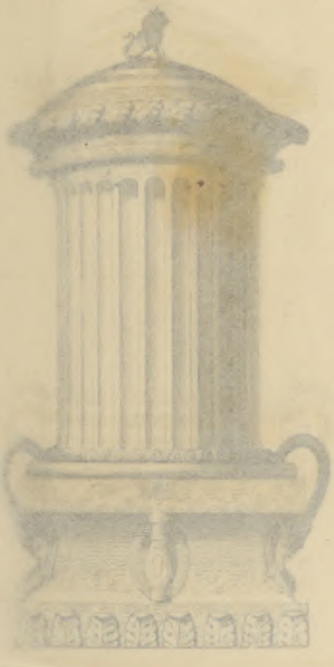
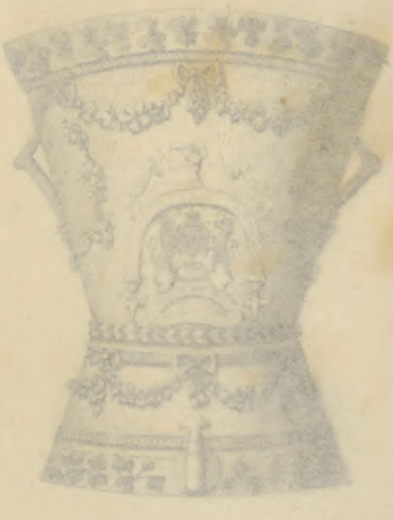


Fig. 15.



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FILTER.

PLATE CCXLV.

Fig. 7.

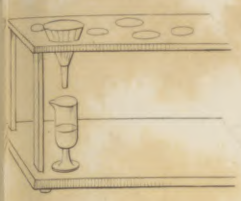


Fig. 2.

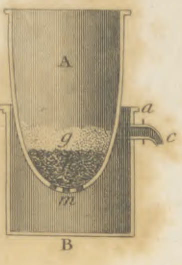
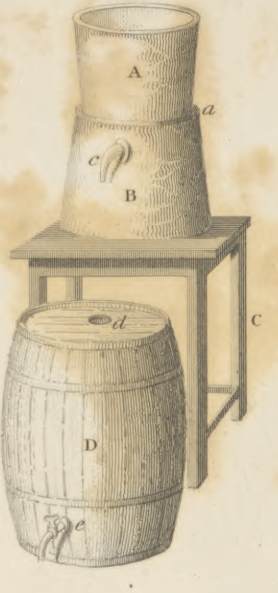


Fig. 1.



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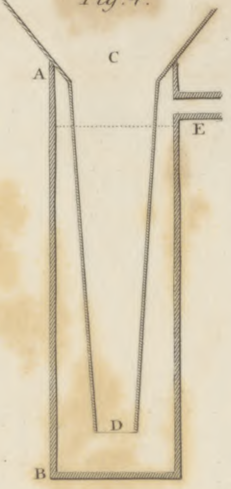

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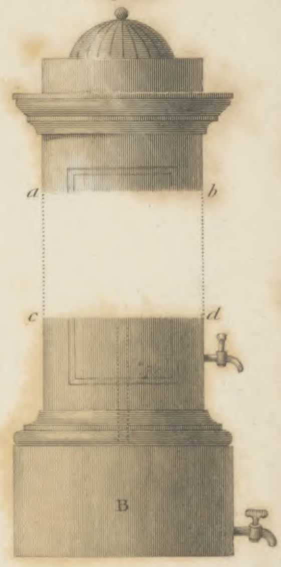

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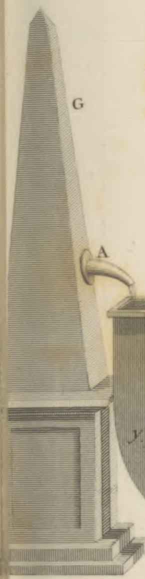
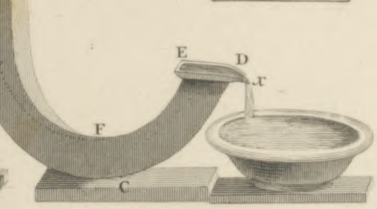

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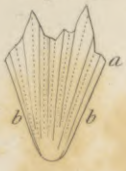

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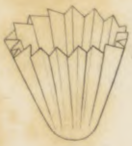

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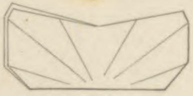

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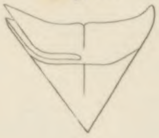

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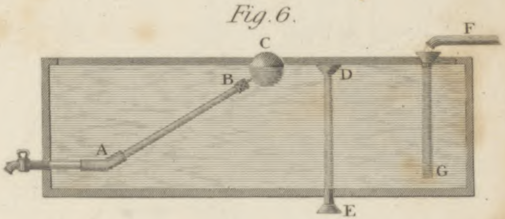

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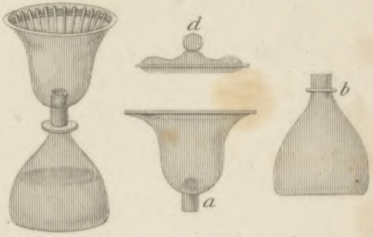
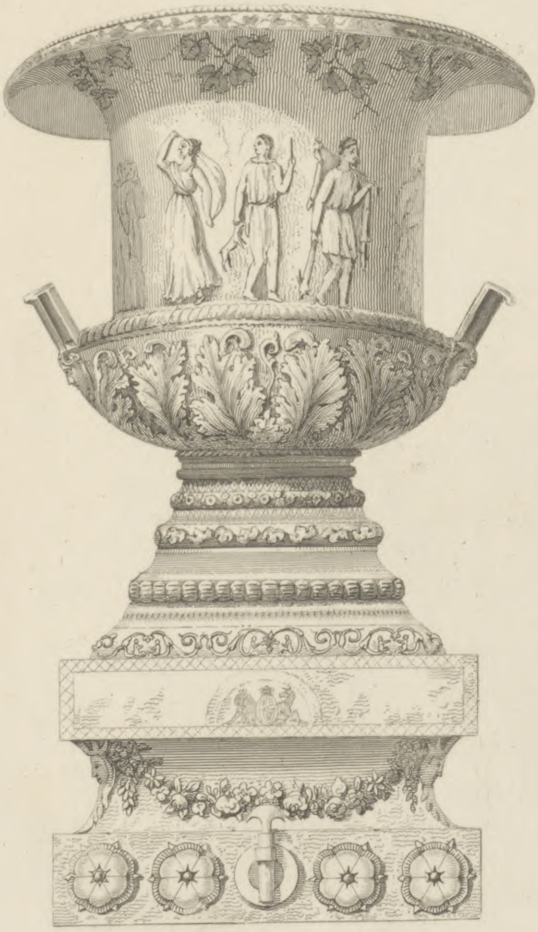


Fig. 13.



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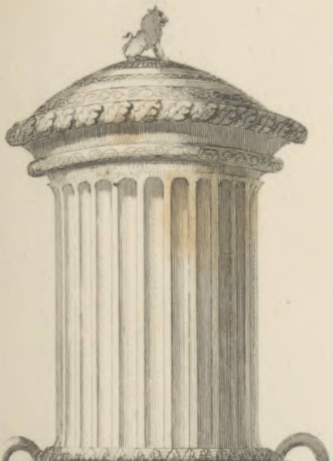
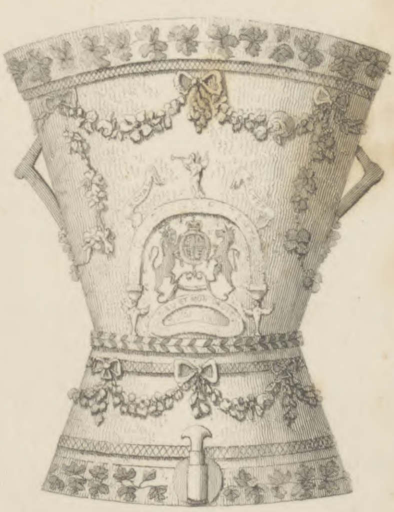


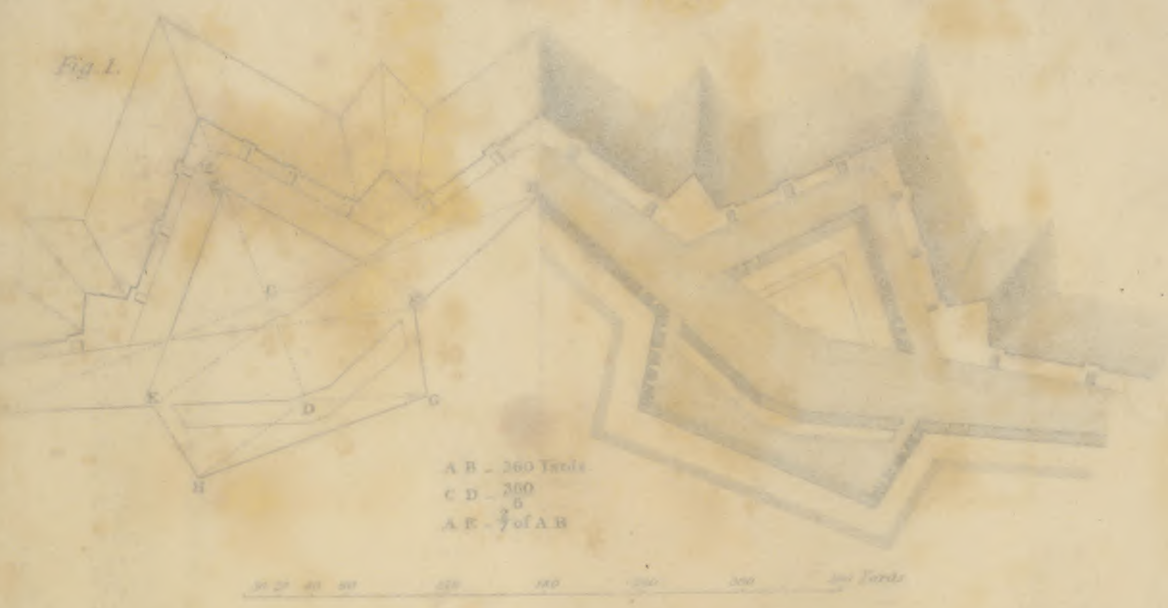
Fig. 15.



Engd by G. Aikman. Edinr

VAUBAN'S FIRST SYSTEM.

Fig. 1.



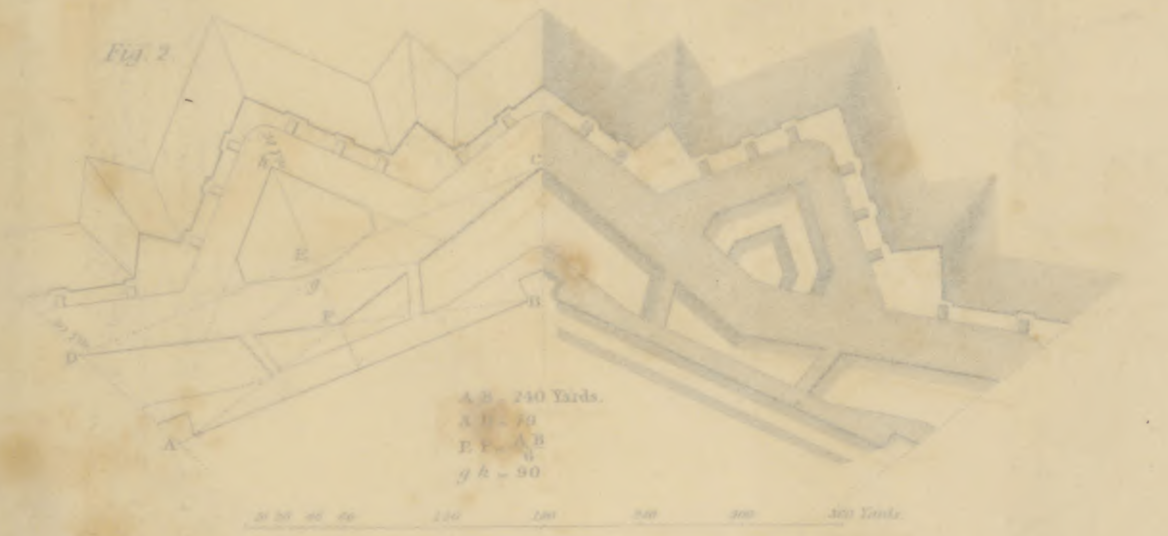
A B = 360 Yards

C D = $\frac{360}{6}$

A E = $\frac{2}{7}$ of A B

VAUBAN'S SECOND SYSTEM.

Fig. 2.



A B = 240 Yards.

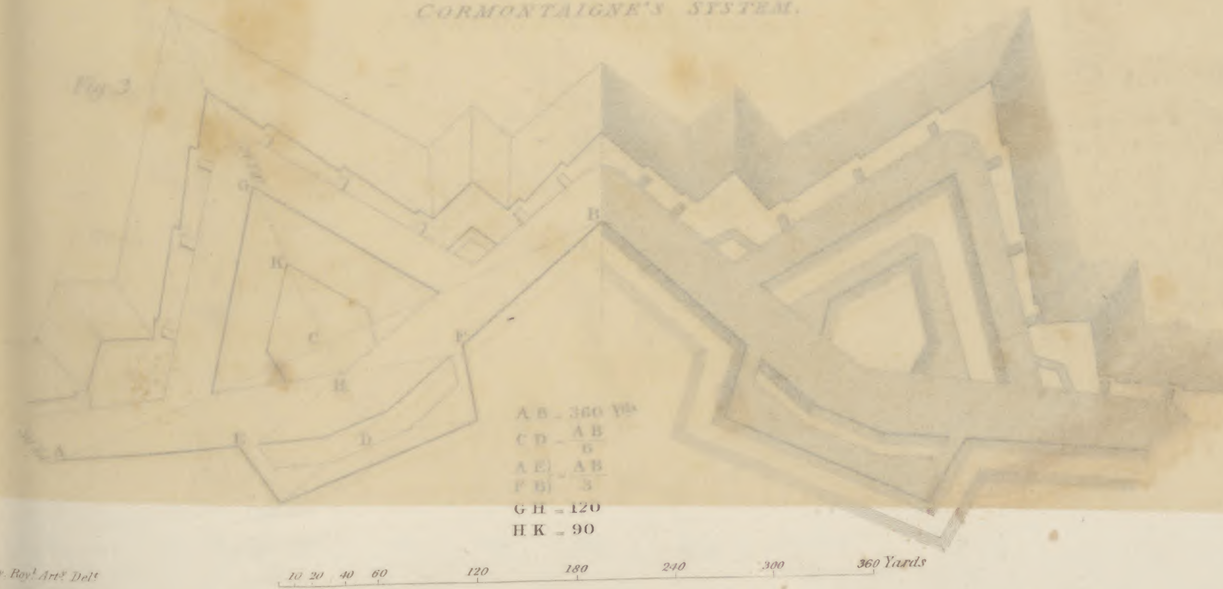
A D = 70

E F = $\frac{A\,B}{6}$

$g\,h$ = 90

CORMONTAIGNE'S SYSTEM.

Fig. 3.



A B = 360 Yds

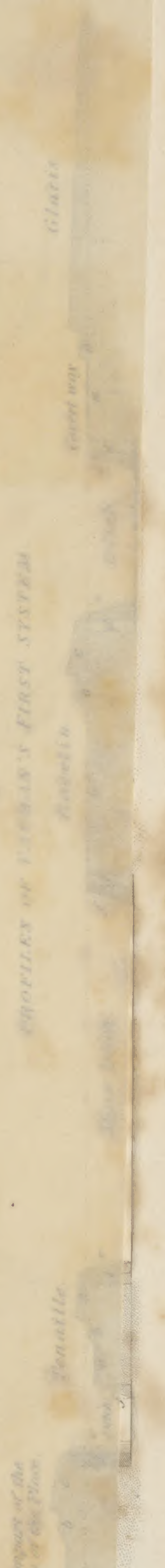
C D = $\frac{A\,B}{6}$

$\left.\begin{array}{l}A\,E\\F\,B\end{array}\right\} = \frac{A\,B}{3}$

G H = 120

H K = 90

Fig. 4.



PROFILES OF VAUBAN'S FIRST SYSTEM.

a. Terre plein, b. Banquette, c. Parapet, d. Revêtment, e. Escarp, f. Counterscarp.

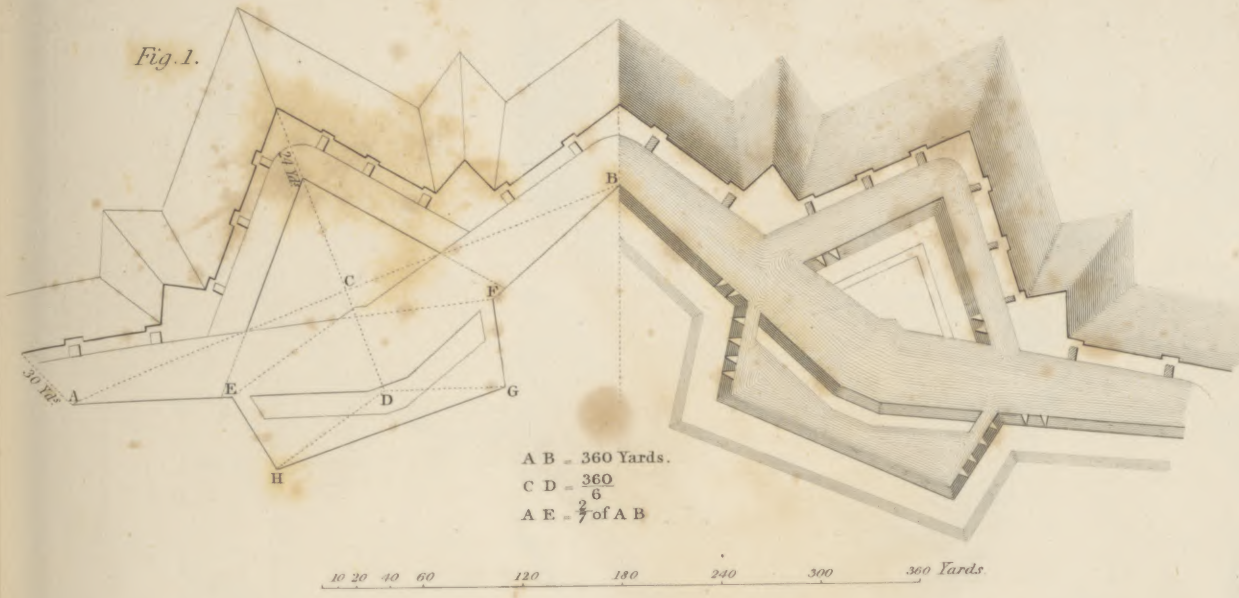
aw. Roy^{l} Art^{y} Del^{t}

Eng^{d} by G. Aikman, Edin^{r}

FORTIFICATION.

VAUBAN'S FIRST SYSTEM.

Fig. 1.



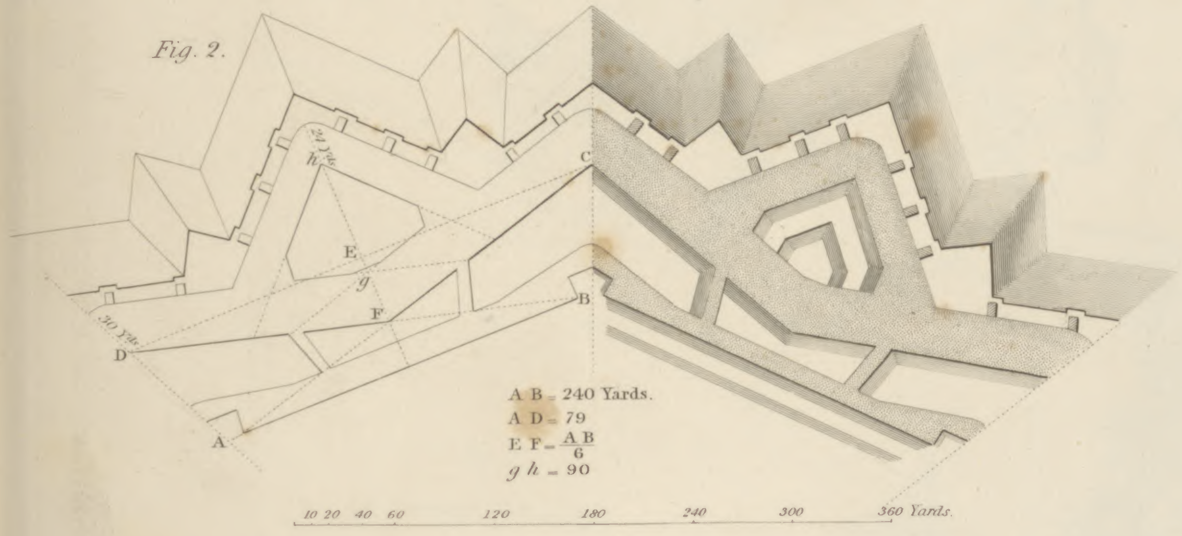
A B = 360 Yards.

$C D = \frac{360}{6}$

$A E = \frac{2}{7}$ of A B

VAUBAN'S SECOND SYSTEM.

Fig. 2.



A B = 240 Yards.

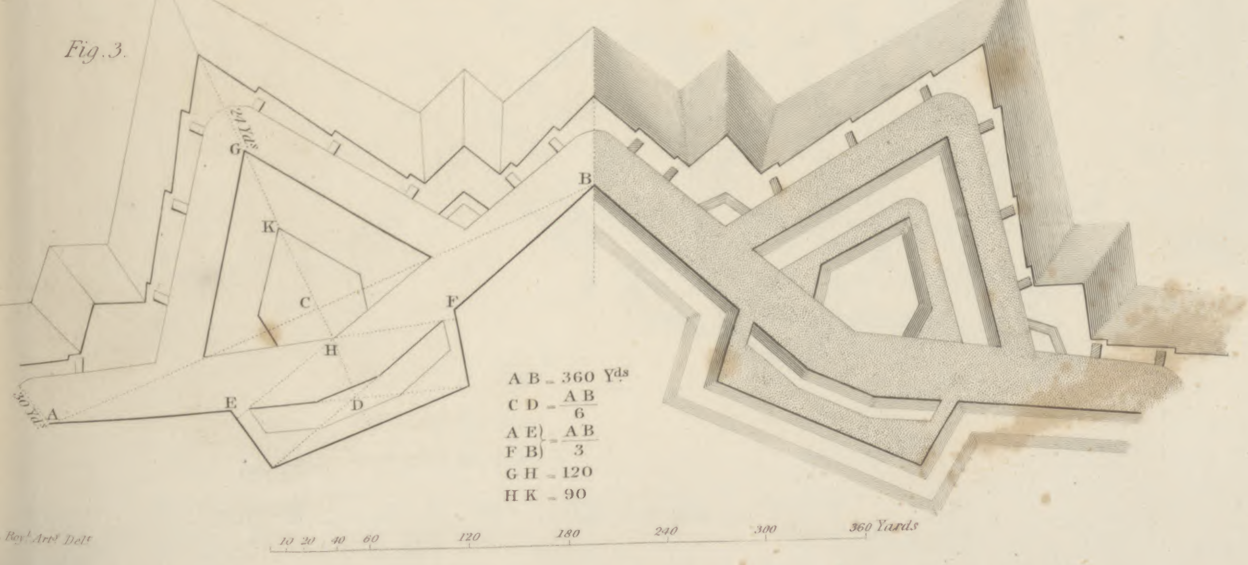
A D = 79

$E F = \frac{A B}{6}$

$g h = 90$

CORMONTAIGNE'S SYSTEM.

Fig. 3.



A B = 360 Yds

$C D = \frac{A B}{6}$

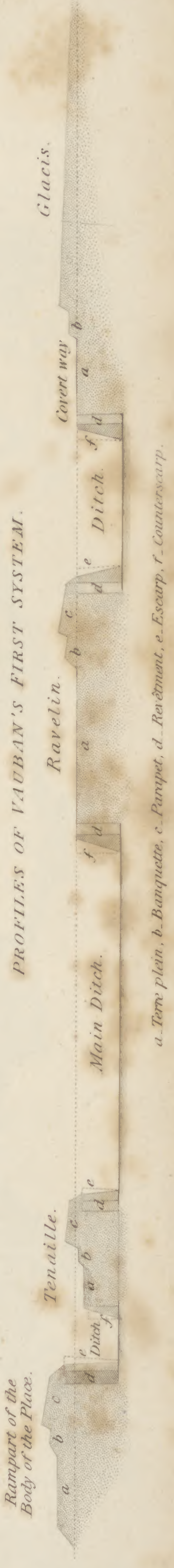
$\left.\begin{matrix} A E \\ F B \end{matrix}\right\} = \frac{A B}{3}$

G H = 120

H K = 90

Fig. 4.

PROFILES OF VAUBAN'S FIRST SYSTEM.



a. Terre plein, b. Banquette, c. Parapet, d. Revetment, e. Escarp, f. Counterscarp.

Cla shaw, Roy^l Art^y Del^t

Eng^d by G. Aikman, Edin^r

FORTIFICATION.

Fig. 1.

COEHORN'S SYSTEM.

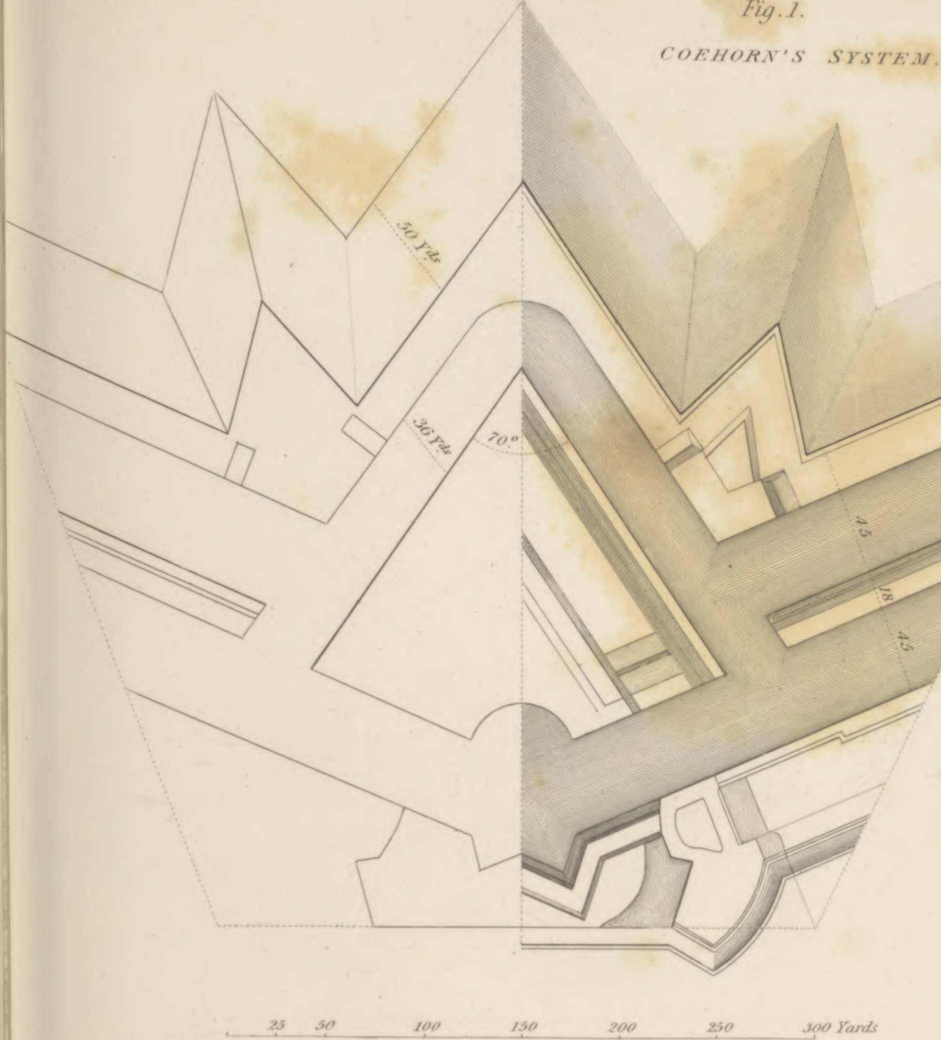
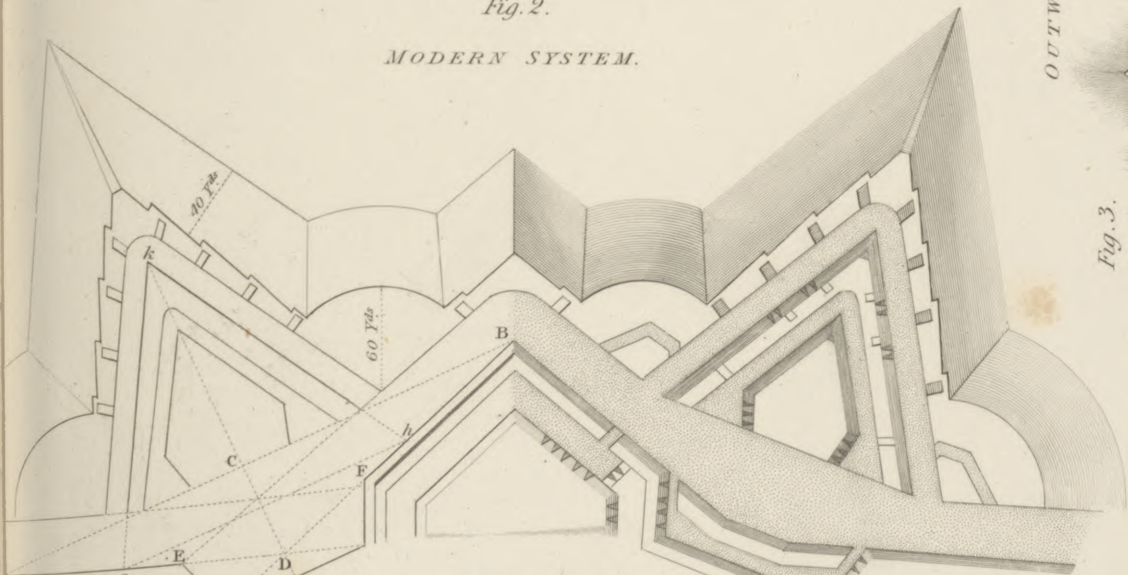


Fig. 2.

MODERN SYSTEM.

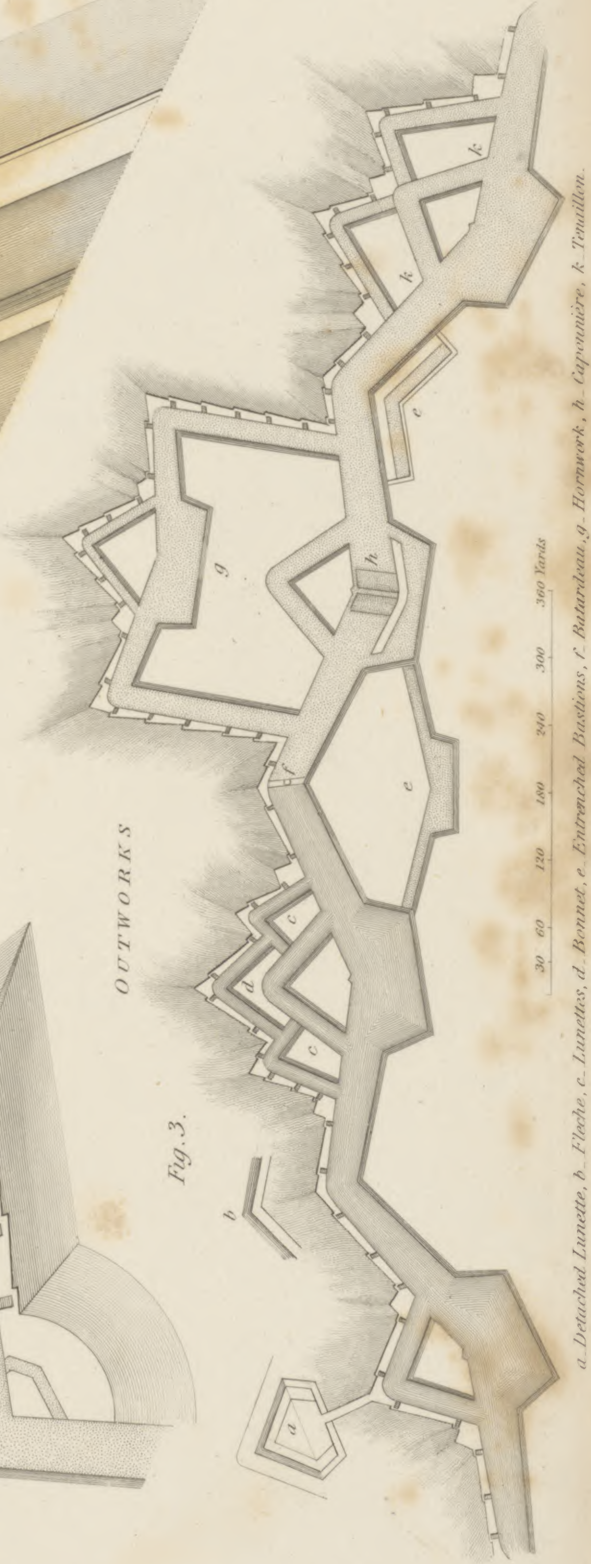


A B = 360 Yards.

$C D = \frac{A B}{6}$

$\left.\begin{matrix} A E \\ F B \end{matrix}\right\} = \frac{A B}{3}$

$g h = g k . h k$



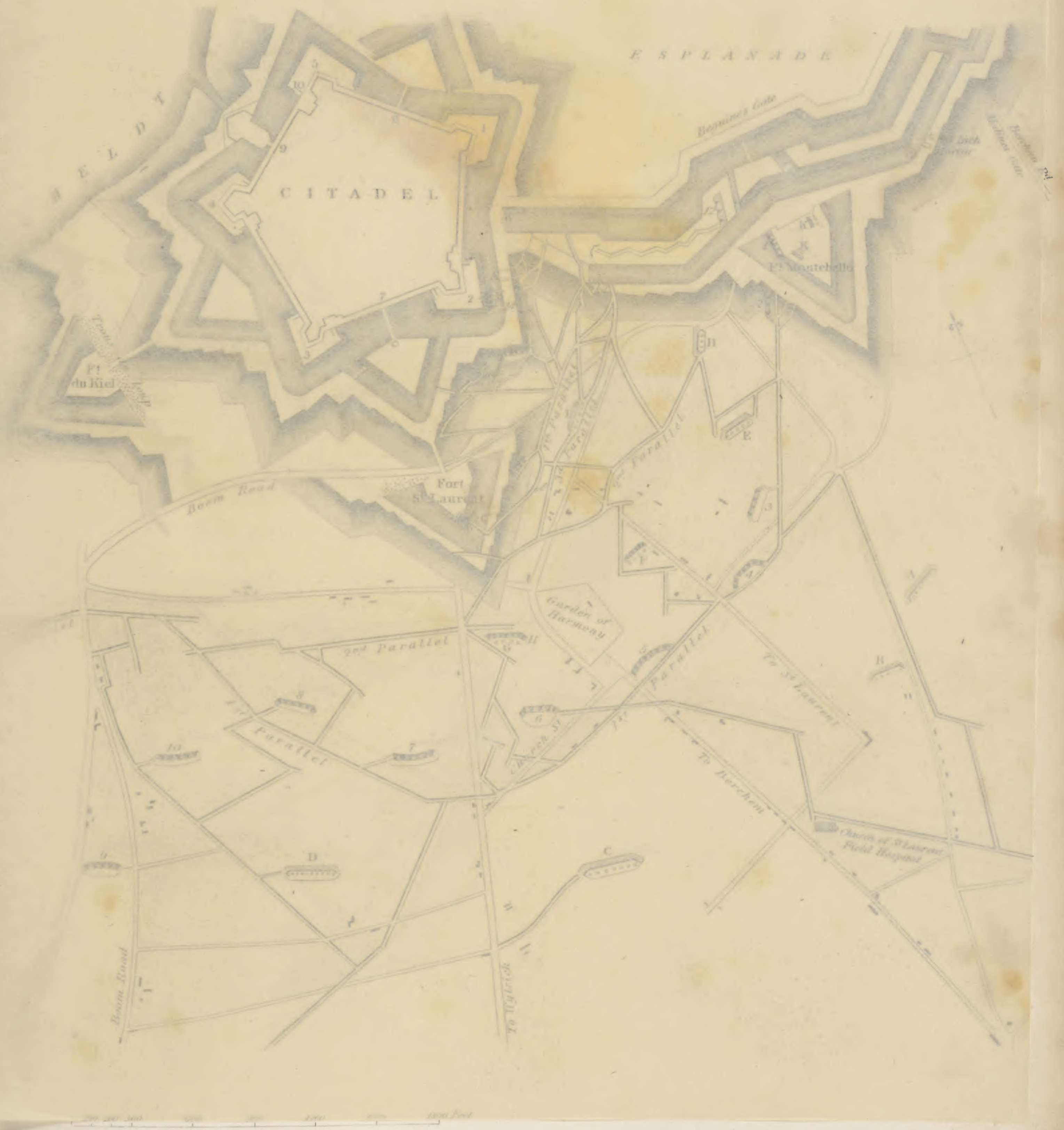
a. Detached Lunette, b. Flèche, c. Lunettes, d. Bonnet, e. Entrenched Bastions, f. Batardeau, g. Hornwork, h. Caponnière, k. Tenaillon.

n, Royl Artl Delt

Engd by G. Aikman, Edinr

PLAN of ATTACK of the CITADEL of ANTWERP, from 29th Novr to 23rd Decr 1832.

1 _ Fernando
2 _ Toledo
3 _ Paciotto
4 _ Duke
5 _ Albe
6 _ Demilune
7 _ Port de Secours
8 _ Port de La Ville
9 _ Port de l'Escaut
10 _ Genl Chassé Casemate
A _ Descent into Ditch
B _ Breach
C _ Descent into Ditch of the Ravelin

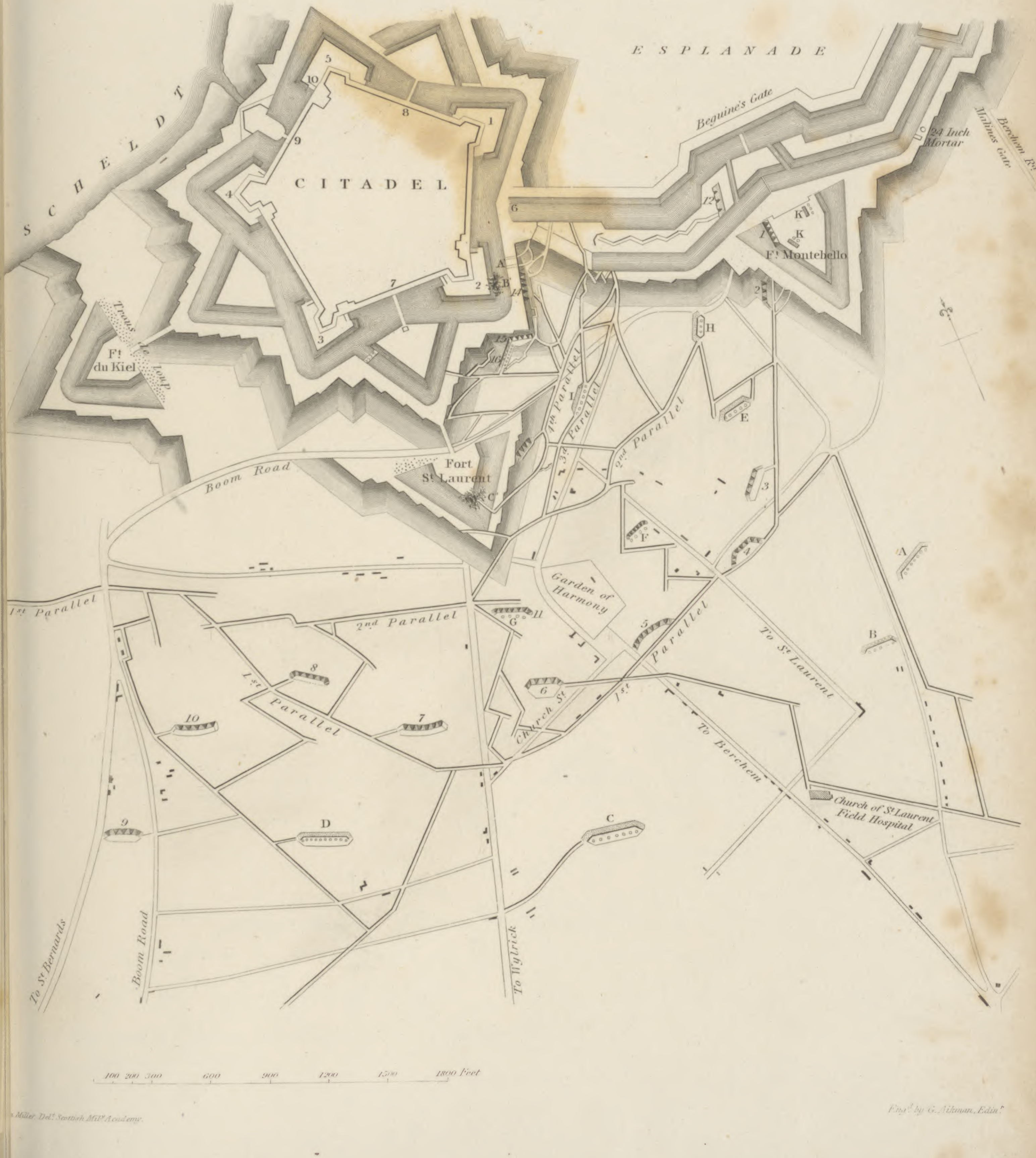


Miller, Delt Scottish Milty Academy

Engd by G. Aikman, Edinr

PLAN of ATTACK of the CITADEL of ANTWERP from 29th Novr to 23d Decr 1832.

1 _ *Fernando*
2 _ *Toledo*
3 _ *Paciotto*
4 _ *Duke*
5 _ *Alba*
6 _ *Batardeau*
7 _ *Port de Secours*
8 _ *Port de la Ville*
9 _ *Port de l'Escaut*
10 _ *Genl Chasse Casemate*
A' _ *Descent into Ditch*
B' _ *Breach*
C' _ *Descent into Ditch of the Ravelin.*



...n Miller, Delt Scottish Milty Academy. *Engd by G. Aikman, Edinr*

FIELD FORTIFICATION.

Fig. 1.

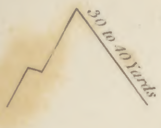


Fig. 2.

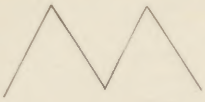
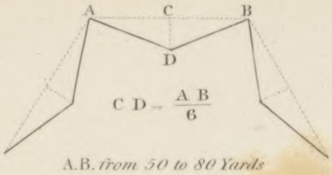


Fig. 3.



A.B. from 50 to 80 Yards

Fig. 13.

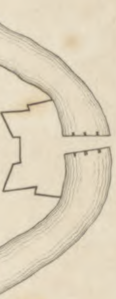


Fig. 4.

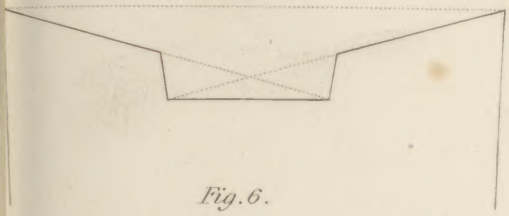


Fig. 5.

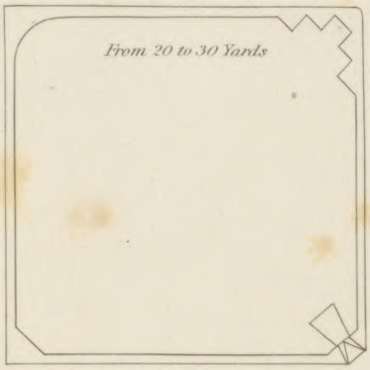


Fig. 6.

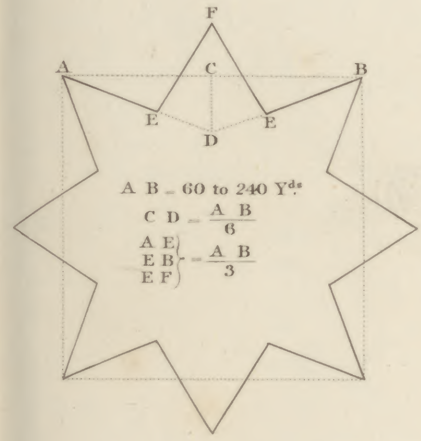


Fig. 7.

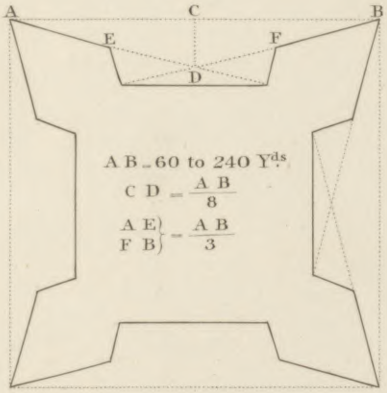


Fig. 11.

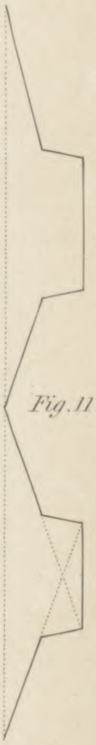


Fig. 12.

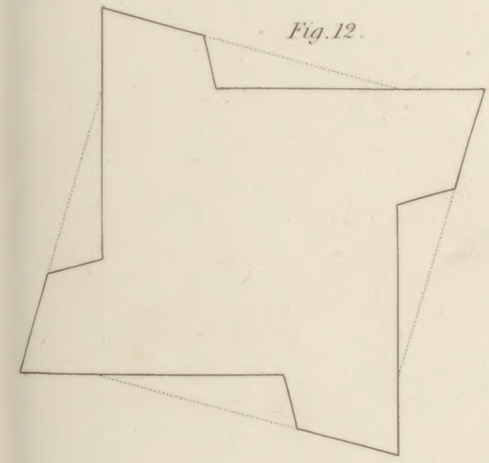
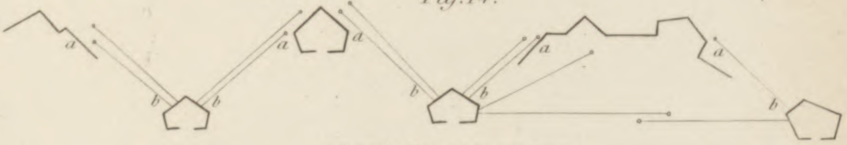


Fig. 14.



a.b. varies from 60 to 150 Yards

Fig. 8.

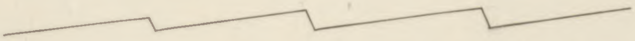
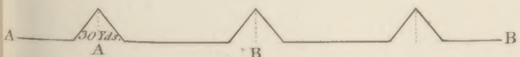
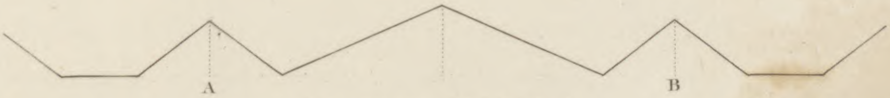


Fig. 9.



A.B. varies from 180 to 200 Yards

Fig. 10.



A.B. varies from 240 to 360 Yards

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